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NORTH AMERICA

CHICAGO NUMBER

• PHILADELPHIA AND LONDON

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Concerning Amputations
By Dr Harry E Mock

Plastic Operations for Hydronephrosis
By Dr William Wallace Scott

THE SURGICAL CLINICS of NORTH AMERICA

CHICAGO NUMBER

SYMPOSIUM ON SURGICAL TECHNIC



FOREWORD

IN this symposium a group of surgeons, active in several fields, have discussed their methods in a variety of operations. Surgical procedure is an attribute as individual as is orthography—"no two surgeons operate alike." The technic of one surgeon, however, is always of interest to his confreres for, consciously or not, comparisons are drawn and there is stimulation of thought. Operative surgery is not a static field—witness the newer procedures devised in recent years for situations previously regarded as beyond surgical attack.

ALEXANDER BRUNSCHWIG, M.D.

THE EARLY MANAGEMENT OF FACIAL INJURIES

WAYNE B SLAUGHTER, M D DDS* AND WAYNE WONG, M D †

THE adequate management of facial injuries is of tantamount importance to the patient from a cosmetic, functional and psychological point of view. The armamentarium of the present day surgeon is such that immediate and proper management of such injuries can greatly reduce undesirable results. The fact that facial injuries are often associated with other bodily trauma that may threaten life itself is often used as an excuse for not treating facial injuries adequately. However one with a premonitory clinical judgment can determine to what degree such surgery can be carried out. The following description is concerned chiefly with the methods used in the treatment of facial injuries as used in our clinic.

A simple classification of facial injuries for the purpose of this paper is as follows:

A Soft Tissue Injuries

- 1 Abrasions tattoo marks
- 2 Lacerations
 - a Scalp and forehead
 - b Eyelid
 - c Nose
 - d Lips
 - e Ear
 - f Tongue

B Simple Facial Bone Fractures

- 1 Frontal
- 2 Nasal complex
- 3 Malar
- 4 Maxilla
- 5 Mandible
- 6 Alveolar ridge

C Compound Facial Bone Fractures

- 1 Frontal
- 2 Nasal complex
- 3 Malar
- 4 Maxilla
- 5 Mandible

PHYSICAL EXAMINATION

The physical examination of a patient with facial injury consists first, of an accurate clinical evaluation of the total injury sustained. As these patients often have associated injuries it is imperative to determine the severity of the injuries in order that those which threaten life itself may be cared for immediately. Sound clinical judg-

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ment is just as necessary here as in any other surgical emergency, because much depends on the speed of making a diagnosis so that the necessary treatment may be quickly instituted. Conditions the control of which may be considered more urgent than the immediate treatment of any facial injuries are hidden hemorrhage, pain and shock. The judicious use of plasma or whole blood is common in adequate shock therapy. The immobilization of injured parts also takes precedence. No set rules can be laid down for the two because such knowledge comes only with experience.

After the general condition of the patient is under control, a systematic examination of the face to determine the extent of the facial injury is in order. The soft tissue injuries may be quite evident, but the bony defects may be deceptively camouflaged by soft tissue swelling. In such cases, gentle bimanual palpation is carried out in such a manner that one side is simultaneously compared with the other.

In order to palpate the bony structures of the face in the best possible manner, one should face the patient. The frontal area is first examined. Then the fingers are brought to bear over the supraorbital rims and moved laterally, eventually palpating the entire orbital rim and always comparing one side with the other. The supraorbital notch must not be confused with a fracture. A displacement of the zygoma will result in a loss of the height of the cheek bone. Next the eyelids are separated and the eyeballs are inspected. If for any reason the patient is not able to see or the eyeball does not appear normal the aid of an ophthalmologist should be sought immediately.

The nasal bones are now palpated to determine any loss of symmetry or to elicit motion or crepitus. Any or all of the bones that go to make up the support of the external nose can be involved in a fracture. This includes the nasal processes of the maxillae and the frontal bones and the nasal lacrimal and ethmoid bones. Fractures of the nose frequently indicate more extensive associated fractures. It is therefore, necessary to examine the maxilla adequately for possible fractures in every case of nasal fracture. An intranasal examination to determine the state of the bony and cartilaginous septum and the lateral nasal wall is imperative.

The maxillary bone, because of its comparative size, can sustain a great variety of fractures. There is a characteristic distortion of the middle third of the face evidenced by a widening or lengthening, or both. By retracting the lips and examining the alveolar process and the regions above, additional information may be obtained. Any displacement or impaction will cause the patient to have a malocclusion of the teeth with open bite appearance and an inability to close his mouth properly. A severe displacement may result in a loss of support of the orbital contents, and a disturbing hyperphoria may develop.

Fractures of the mandible can often be determined by having the patient attempt to open and close his mouth. If he can do this with

ease, the possibility of a dislocation or a severe fracture associated with trismus is ruled out. Palpation of the mandible is started at the region of the temporomandibular joint, down the posterior border of the ramus and hence to the body of the mandible. Discovery of pain, crepitus or malposition may point to a fracture. The careful inspection of the teeth in occlusion will often point to the site of fracture. X-ray examination may be necessary to actually localize the fracture, and it is an indispensable aid in confirming a diagnosis.

From a diagnostic and medicolegal aspect it is a wise procedure to obtain x rays of the skull in any severe head injury. The possibilities of any retained radiopaque foreign bodies may thus be quickly determined.

TREATMENT OF FACIAL INJURIES

The treatment of facial injuries may be conveniently classified into immediate, delayed and late treatment. Immediate treatment is that which is instituted within the first few hours after injury and includes the management of shock, the control of hemorrhage, the relief of pain and the splinting of injured parts. Much of the treatment given during this period to a large extent determines the ultimate cosmetic and functional results the patient is to obtain. Strictly speaking, it is during this period that the maximum service will be rendered to a patient. It is therefore mandatory that what is done for him should be the best possible treatment under the given circumstance.

In general it may be said that in a wound obtained under relatively clean conditions primary suture if done within a period of six hours after injury, should result in an uneventful healing. This period of six hours is entirely arbitrary and depends upon the nature of the injury. If the wound was obtained in surroundings where everything was relatively clean closure may be done as late as eight hours after the injury. On the other hand, if it was a dirty wound this time must be reduced to four hours. After this period of four to eight hours organisms already have invaded the tissues and the chances of infections are greatly enhanced. The advent of sulfonamides, however, has greatly changed this picture. In a borderline case, the local use of a sulfonamide will readily subdue the bacteria flora in the stage before the inoculum of bacteria has gained a foothold and also when there is no protein digestion to hinder the action of sulfonamides. The sulfonamide must be in such a form as to be sterile as well as nonirritating to the tissues. The amount actually instilled in the wound should be the bare minimum. If there is any doubt about the degree of contamination oral administration should be started.

The use of penicillin in the presence of organisms susceptible to it has practically removed the obstacle of infection in wound healing. Soft tissue wounds of several days' duration even though infected or actually purulent, may be closed primarily if adequate amounts of penicillin are given locally and systemically. Thus it is seen that the

use of sulfonamides in fresh wounds may be indicated, but when the growth of bacteria has started and protein destruction has set in, the action of sulfonamides is greatly diminished and penicillin should be used. Penicillin thus has a role as the primary drug and as a supplement to the sulfonamides.

In the region of the face there are several additional factors that make wound healing slightly different from elsewhere in the body. These include an abundant blood supply, which is definitely a positive factor in wound healing, and the local tissue immunity to the organisms that the patient harbors in his mouth, nose and eyelids.

The cleansing of the facial wounds, like wounds elsewhere, should consist of gentle cleaning with a mild soap and irrigating with sterile saline or water. An arbitrary period of five to eight minutes for scrubbing the wound will be sufficient to remove any loose or recently implanted debris from the wound and the surrounding skin. Gentleness must be stressed in this procedure. The use of the popular antiseptics is permissible on the skin surfaces, but they should not be instilled into the wound, as these substances act as protoplasmic poisons and can kill living tissue just as well as the organisms that contaminate the wound. If facilities are not immediately available for the proper cleansing of the wound, a sterile or clean dressing should be used to cover it until such are available. Injudicious pouring of antiseptics into the wound should be condemned.

TREATMENT OF SPECIFIC FACIAL INJURIES

Abrasions—The most common facial soft tissue injury is the simple abrasion. In its minimal aspects no treatment is required other than cleanliness. However, when dirt and debris are ground into the tissue, it is important to remove these particles so that unsightly tattoo marks may be prevented. If ordinary sedation is not sufficient for the purpose, a general anesthetic may be necessary for the removal of the embedded particles. An oil solvent is often helpful in dissolving out oily debris. It may be necessary to use a brush over the area with sufficient sterile water to irrigate the region. Oftentimes it may be more expedient to use a pointed instrument such as a No. 11 Bard Parker blade or the point of an aspirating needle to remove these particles individually. When the abrasion is sufficiently cleansed, a fine mesh, mildly antiseptic petrolatum gauze pressure dressing is applied in such a manner as to act as a splint, even though this may require the immobilization of the facial muscles.

Lacerations—Lacerations about the face are peculiarly different from those elsewhere on the body because the patient desires a cosmetic as well as a functional result. This fact is further complicated by several specialized structures that must be especially cared for. These structures are the scalp, eyelids, nose, lips and ears.

Scalp lacerations need no particular precaution in their care other

than a thorough cleansing with soap and water. It is usually not necessary to shave the hair about the laceration before suturing, but by merely parting the hair in line with the laceration, interrupted sutures can be easily placed, and healing is very prompt. If the laceration is of any size, it is advisable that a pressure dressing be applied over the wound for a period of forty-eight hours or longer to prevent the formation of a hematoma under the skin flaps.

A type of laceration that occurs rather commonly in the region of the scalp and forehead is the so-called stellate laceration. The force causing this injury is directed perpendicular to the scalp surface and compresses the tissue against the cranial bones. Over the forehead where the end results of such laceration are somewhat disfiguring to say the least, it is cosmetically important that a minimal scar be obtained. This type of laceration is difficult to suture with any degree of care because of the multiplicity of the lacerated edges. When it occurs on the forehead, it is best treated by converting it into a single line scar by excision of the fragmented edges and undermining the wound so that the scar will preferably be in the horizontal meridian, following the lines of Langer.

The most important point in the suturing of facial wounds next to obtaining functional results, is to obtain desirable cosmetic results. The excessive formation of scar tissue is not compatible with good cosmetic results. In order to minimize the formation of scar tissue it is of utmost importance to remove all tension from the skin edges themselves. This is done by adequately undermining the laceration and by placing interrupted buried fine silk, catgut or cotton tension sutures (Fig. 1). If the laceration is from the skin through the mucous membrane surface, this tension suture is a figure-of-8 suture (Figs. 2 and 3) with the knot on the mucous membrane surface. When tissue tension is thus minimized, the skin edges are brought together with continuous subcuticular stitch of some nonabsorbable material such as nylon, horsehair or steel, preferably on an atraumatic needle.

Where the skin edges are not in perfect apposition, horsehair sutures with a double twist or friction knot are sufficient to correct this defect. The horsehair tied in this manner affords some give to the knot to allow for tissue swelling, and in this manner it tends to reduce scar formation due to localized pressure of the sutures. The normal healing wound is usually agglutinated in twenty-four to forty-eight hours, at which time these interrupted horsehair sutures may be removed. A firm pressure dressing is then applied over the wound to further aid in splinting the tissues. If the wound is over a region where jaw movement will cause undue tension, the jaw should be adequately immobilized for five to seven days.

Lid lacerations should be repaired with much care in order to prevent any disfiguring notching, cicatricial ectropion, and subsequent exposure keratitis. These are most often caused by vertical lacerations

Fig 1

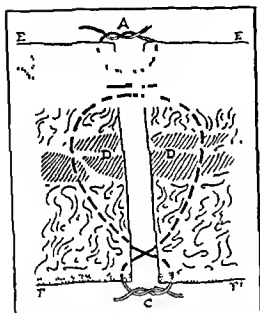
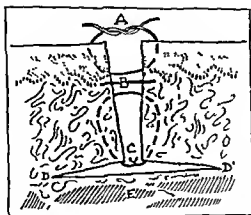


Fig 2

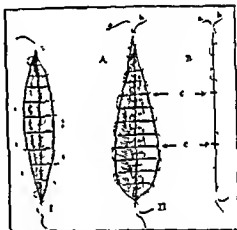


Fig 3

Fig 1—Technic for closure of lacerations to avoid tension on skin edges A, Horsehair friction knot (double twist) B, Usual depth of continuous subcuticular suture (nylon, silk or wire) C, Principal tension suture with surgical knot at depth of laceration Tension is on this suture and not on A or B D, Undermined region to aid approximation E, Muscle layer

Fig 2—Technic for closure of full thickness lacerations involving skin and a mucous membrane surface (lips, cheeks, ala, etc) A, Horsehair friction knot on skin surface (E-E) B, Depth of subcuticular suture C, Figure-of-8 suture upon which is placed the principal tension load Started on the mucous membrane surface (F-F) the suture is placed so that the muscle mass (D-D) on either side of the laceration is incorporated in a manner to allow maximum approximation of muscle tissue and least amount of tension on skin surface This suture is tied with a surgeon's knot

Fig 3—Halsted's intradermic or subcuticular suture, employed when especially fine scar is desired I Needle introduced 0.5 cm beyond one angle of wound and brought out at end Needle engages corium at points 0.5 cm apart, until entire wound is traversed Suture then brought out 2 or 3 cm beyond angle of wound, needle being kept close to skin and at the same level on both sides II Double suture A, a, Deep suture A, b, Superficial suture B, Suture tied c, c', Superficial suture brought out on skin surface every 2 or 3 cm to facilitate its subsequent removal (Sinnott-Fomon)

involving one or both lid margins. Such lacerations may be caused when a blunt object is thrown against the eye. The anticipation of the oncoming blow results in a protective contracture of the orbicularis oculi which thus holds the tarsi rigid. When the blow arrives, the more solid tarsus is split by the force, and the subsequent contracture of the orbicularis oculi pulls the wound apart, thus resulting in the characteristic V shaped lid laceration. Such lacerations are best repaired by taking a bite with a fine full curved atraumatic needle 3 to 4 mm from one lacerated edge on the intramarginal sulcus of one side, through the plane of the tarsus, to emerge through the intramarginal sulcus on the other side about 3 to 4 mm from its lacerated edge (Fig 4). With

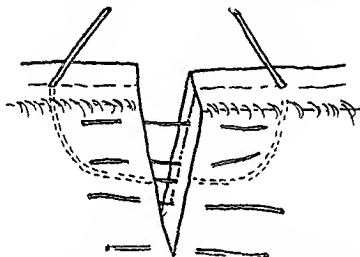


Fig 4—Diagram of a V shaped laceration of lid margin. The first and important suture is the one that is taken in the plane of the lid beginning 3 or 4 mm from the lacerated edge on the gray line of one side to emerge through the gray line on the other lacerated edge about 3 to 4 mm from its edge. With this suture in place, interrupted horsehair sutures for the skin surface and fine silk sutures for the conjunctival surface may readily be inserted. A pressure dressing is then applied.

this suture in place but not tied for the moment, it can be used as a traction suture, and the conjunctiva and skin may be separately sutured with greater ease. A petrolatum dressing can then be applied over the lid and a moderate pressure dressing applied. In every laceration about the eye, one should always examine the eyeball to determine the extent of possible ocular injury. If vision is lost, or if for any reason the eyeball does not appear normal, the aid of an ophthalmologist should be sought immediately. In the interval, the mere use of a sterile dressing over the eye will suffice as purposeful neglect will do less harm than inquisitive manipulation.

Lacerations about the nose that involve the lateral borders of the nares and the columella must be accurately approximated because

minor differences in symmetry can readily be noticed. Care in suturing with the proper needles will usually give satisfactory results. Lacerations involving the tip of the nose must not be heavily sutured as this may impair the blood supply and hinder healing. The presence of deep sebaceous glands in this region invites infection, it is therefore advisable not to bury any sutures here, but simply to close the wound with interrupted nonabsorbable sutures. Collodion dressing on the surface to further aid in stabilization is indicated.

In *vertical lip lacerations* one should first approximate the laceration by accurately matching the mucocutaneous line of one side with that of the other. Tension sutures of the "figure-of-8" variety should be placed, and then the skin may be approximated with interrupted horsehair sutures tied with a single friction knot. No dressing is needed over these areas, as any dressing is readily soiled by saliva, but if a dressing is desired, a small collodion impregnated cotton dressing on the skin surface only is satisfactory.

Lacerations of the tongue heal readily. Mere puncture wounds, if they are not bleeding, require no suturing. Larger lacerations, especially if they involve the margin of the tongue, usually require suturing. The use of a minimal number of interrupted silk sutures to adequately approximate the tissues and maintain hemostasis will suffice.

Ear lacerations are difficult to repair because they are usually caused by an avulsive force so that the lacerated edges are fragmented and beveled. It is not wise to trim any of the fragmented and oftentimes semimacerated skin, for one will usually be left with an embarrassing insufficiency of skin to cover the cartilage. It is necessary that the cartilage be in accurate apposition before the skin is sutured, otherwise a terraced effect will result from the overlapping. After a careful approximation is made, the next hazard is the prevention of an auricular hematoma. A dental mold impression of the posterior surface of the ear is made, and a relatively firm dressing may be used over this mold. It is sometimes necessary to weigh the benefits of pressure against the dangers of ischemia, especially when local tissue cyanosis is noted.

It is possible to repair nearly all soft tissue injuries about the face by means of local anesthesia, infiltration or nerve block. If the lacerations are seen early, suturing may be done without anesthesia, as the anesthetizing effect of the trauma coupled with psychic shock of the accident will often have an analgesic effect. The use of local infiltrative anesthesia (1 per cent novocaine with adrenalin 1:10,000) does not have any noticeable effect in wound healing or in scar formation,

FRACTURES

The management of facial bone fractures may be started immediately after the more impending injuries are cared for. This may be anywhere up to forty eight hours after injury, but even after this

period one can safely and adequately treat these fractures. The earlier these fractures are reduced, the lower the incidence of infection. This is particularly true of fractures of the mandible.

The severity of facial bone fractures, more particularly the transverse facial bone fracture, may be such as to entail the combined knowledge of a neurosurgeon, an otorhinologist and an oral surgeon. In the average civilian practice, however, such cases are rare because when these cases are encountered, the number that survive to receive treatment of their facial fractures is small. In a series of 300 consecutive cases of facial bone fractures treated in a civilian hospital, the incidence of fractures of the various facial bones was as follows:

	Per Cent
Mandibular	86
Zygomatic	5
Transverse facial	4
Nasal	2
Condylar	2
Frontal	0.5
Coronoid	0.5

A short description of the methods used in the treatment of various facial bone fractures is herewith given. Treatment must be preceded by definite clinical and roentgenographic evidence of a fracture, otherwise the situation may be embarrassing. To illustrate this point, a patient with a definite history of trauma to his jaw which was followed by a pronounced swelling and marked trismus, was admitted with a diagnosis of a fractured jaw. The history and clinical finding suggested a fracture at the angle of the mandible, with a deep-seated abscess or hematoma. However, when numerous radiographs were taken, no fracture line could be found. The blood serology was found to be positive, and clinical evidence of a fracture at the angle rapidly disappeared with the proper antiluetic therapy.

Frontal Bone—A depressed fracture of the frontal bone may be of no particular consequence if the depression involves only the outer cranial plate. If the inner cranial plate is involved and symptoms of cerebral compression are present, the problem is a neurosurgical one. The force that causes a depressed fracture of the orbital rim nearly always makes it a compound one. If the fragment is displaced downward, it may be replaced by digital manipulation or an open reduction. The exposure of the frontal sinus and also the possibility of the cranial vault being entered, makes the prophylactic use of the sulfonamides or penicillin imperative. The surgical replacement of a depressed fragment or traction made to an appliance is only rarely indicated. If a depressed fracture of the outer plate of the frontal bone is seen several days after the accident, and there is no evident complication, it is safe to permit the wound to heal, and at a later period

the frontal defect may be filled with autografts of medullary bone from the crest of the ilium or homografts of diced cartilage

Zygomatic Bone—A depressed fracture of the zygomatic bone causes a marked disfiguring facial asymmetry which results in the loss of the height of the 'cheek bone' and the distortion of the orbital contour. The force that causes this type of injury does not usually create a compound fracture. These fractures may be safely reduced even several days after the accident. Their reduction in the average case is made by placing an elevating instrument beneath the bone, and then raising the fragment into position. This instrument may be inserted either through a stab incision in the buccal fold next to the third

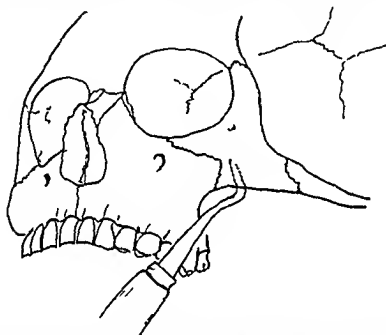


Fig 5—Method of elevating depressed zygomatic bones advocated by Straith. Under local anesthesia a small incision is made high in the mucobuccal fold in the region of the upper third molar. A suitable instrument, somewhat as shown is inserted into this incision and up under the depression which can generally be manipulated into place.

molar and thence under the malar bone (Fig 5), or by Gillies method, through a small incision in the parietal region in the hair bearing area. The instrument is made to slide over the temporal muscle and then under the zygoma. In the latter maneuver, the use of a suitable sized object under the elevating instrument as a fulcrum will greatly ease the manipulation. In recalcitrant cases it may be necessary to do an open reduction and anchor the zygoma to the frontal bone with wire.

Nasal Bone—A depression and lateral displacement of the bridge of the nose is the usual type of nasal fracture. Such cases are readily corrected if seen early. For anesthesia, the nasal cavity is packed with a

4 per cent cocaine pack, and this is supplemented by a subcutaneous injection of 1 per cent novocaine over the bridge and lateral walls of the nose. The cocaine packs are then removed, and a rubber protected hemostat or similar instrument is inserted into the nasal cavity and the depressed fragment elevated and maneuvered into position by digital manipulation. An intranasal splint is placed under the depressed fragment, and an external molded splint is placed to hold the fragments in place. The intranasal splint or packing is removed between forty eight



Fig 6

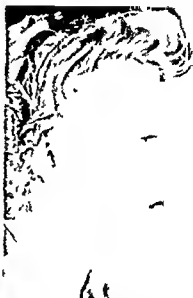


Fig 7

Fig 6—Traumatic "saddle nose" Failure to reposition fractured nasal bones can result in this type of a deformity

Fig 7—Refracture of the nasal bones to realign the structures plus the use of cartilage to substitute for lost structures can give a satisfactory cosmetic result. However this lengthy procedure could be avoided if proper treatment is instituted following the trauma

and seventy two hours later, to prevent pressure necrosis of the nasal mucous membrane. The external splint may be left on for a week (Figs 6 and 7)

In severely compounded and depressed nasal fractures, where it is not possible to use any externally molded splint, it may be necessary to use a U shaped appliance with one of the arms of the "U" holding up the depressed fragment, and the other arm attached to a headcap appliance. If such an appliance is not immediately available, it may be a wiser procedure to reduce the fracture in as simple a manner as possible and suture the skin over it with interrupted sutures. After

the wound is healed, a rhinoplastic procedure may be performed (Figs 8 and 9)

Maxillary Bone—Fractures of the maxilla may vary from a simple puncture wound of the maxillary sinus to a severe impaction or displacement. Such fractures may tax the mechanical ingenuity of the surgeon to construct a proper appliance for fixation. The problem is further complicated in an edentulous patient. No single method can be used for all types of fractures but each case must be studied in its own light. If the mechanics of the fracture is understood the treatment



Fig 8



Fig 9

Fig 8—Traumatic displacement of the nose to the left and failure to realign after injury can result in this type of deformity. The line represents the position of the dorsum as normally seen.

Fig 9—The nose can be replaced in a more normal position but to do this requires a complete nasal plastic operation, a procedure that can be avoided if the proper realignment and fixation are carried out at the time of the original accident.

will be evident. The multiplicity of methods of treatment is evidence of this fact.

In a simple puncture wound of the maxillary sinus the wound is cleaned and freed fragments are removed. The skin over the area is then carefully sutured. No gauze should be packed into the sinus cavity as this would interfere with the normal action of the ciliary epithelium (Figs 10, 11, 12 and 13). If there is a pronounced comminution gauze packing may be used to hold the fragments in position. The packing may be removed gradually over a period of days.



Fig 10



Fig 11



Fig 12

Fig 10—Crush injury results in a complete transverse facial fracture with loss of spinal fluid apparent. The upper jaw has lost all its bony attachments and the weight of the tissues causes the upper jaw and nose to drop down.

Fig 11—Any attempt to swallow or breathe causes additional trauma to the tissues. Surgical principles that apply to all other fractures apply here—immediate reduction.

Fig 12—A headcap applied and the upper jaw fixed to the skull. No attempt is made to interfere with drainage of cerebrospinal fluid by closing the soft tissue defect. The tissues are approximated but not closed. Uneventful postoperative course.



A



B

Fig 13—A Transverse facial fracture similar to Figure 10 but seen immediately after injury. An open reduction following Adams' technique was carried out plus closure of the soft tissue wound. There was no gross evidence of loss of cerebrospinal fluid. B Final results.

In a severely impacted fracture of the maxilla, one can sometimes move the fragment by simply grasping the teeth and loosening the impaction. If this is not possible, one must resort to the use of traction with rubber bands over properly constructed arch bars. When reduction is obtained, fixation is maintained by wiring the teeth of the maxilla to those of the unfractured mandible, the occlusion of the latter being a guide to the proper reduction.

In marked downward displacement of the maxilla, the Lederspiel method or any method that will accomplish the same purpose may be



Fig 14



Fig 15



Fig 16

Fig 14—A possible skull fracture is no excuse for delay in treating facial injuries. This case includes a depressed right zygomatic arch, a transverse fracture of the upper jaw, and a fracture of the lower left jaw, together with fractured teeth and a large opening into the left maxillary sinus. All were treated immediately following injury.

Fig 15—The wound was cleansed thoroughly, the bones stabilized in approximately normal position, and the laceration closed. A headcap was applied to hold a wire that aided in stabilizing the upper jaw and right zygoma. External pin fixation was utilized for stabilization of the fracture of the left mandible.

Fig 16—The final result obtained at six months following the accident. A large opening persisted in the floor of the left maxillary sinus at the site of the upper left first and second molars. At the time of the accident, these teeth were fractured and a large portion of the alveolar ridge was lost. This opening was closed with a double pedicle flap from the palate.

used. In the former procedure, a half round arch bar is wired to the buccal surface of the maxillary teeth. A loop of stainless steel wire is then placed around the arch bar in the region of the second premolar tooth on each side. The wire is carried upwards through the buccal fold and made to emerge just lateral and inferior to the outer canthus. Local infiltration of 1 per cent novocaine makes this procedure painless. The free ends of the wires are then attached to a bar in the plaster headcap, and the traction is made in the direction that will best correct the displacement, by twisting the ends of the wire over

attachments in the headcap. Once occlusion is obtained, it may be maintained by proper wiring of the teeth, with the use of the mandibular teeth as a guide and splint (Figs 14, 15 and 16).

Mandible—The mandible is the most frequently fractured of all the facial bones. Its architectural structure is such that any force striking it is transmitted along its substance in such a manner that, if this force is great enough, it is likely to form a fracture not only at the site of the impact but also on the opposite side. Thus, if a fracture is found in the region of the mental foramen of one side, one should always suspect a fracture near the angle on the opposite side. The frequency of fractures in the various parts of the mandible is given in the following order: (1) the region of the angle, (2) the mental foramen, (3) molar, (4) symphysis, (5) condyle and (6) coronoid.

Treatment consists of attempting to establish and maintain normal occlusion in such a manner as not to hinder swallowing or obstruct breathing. This may be done in a temporary manner by an elastic bandage until a more adequate means of fixation is available. Bandaging is of little value if there is some displacement of the fragments. Other types of fixation that may be used are wiring of the teeth, external skeletal fixation and specially made dental splints.

Mandibular fractures are generally considered to be compounded either in the mouth itself or through a tooth socket. At least 95 per cent of such fractures have been estimated to be thus compounded, and therefore the incidence of infection should be very high. Early fixation within four to six hours will aid in preventing the destruction of tissue and greatly reduces the incidence of infection. Thus if fixation is done early, less than 10 per cent of the fractures develop complications, whereas, if this is delayed a week, the incidence is over 60 per cent. Surgical drainage of an abscess resulting from a mandibular fracture preferably should be extraoral rather than intraoral, and in any case it is never carried out until all the surgical indications for incision and drainage are present.

Alveolar Process—In children and young adults, a severe blunt force oftentimes dislodges the entire anterior alveolar process, so that on clinical examination there is a decided mobility of the entire dental arch. In such cases, any fragment having an attachment to soft tissues should be retained. Fixation to the adjoining teeth may be necessary to maintain stabilization. The regenerative power of the alveolar process is very great and oftentimes a seemingly hopeless fracture surprisingly may regenerate into a firm and useful ridge.

In facial injuries there is much to be gained cosmetically and psychologically by plastic procedures after functional results are obtained. Surgical reconstruction of facial deformities of course is limited in its ultimate results. It is impractical to subject a patient to numerous and lengthy operative procedures when the end result will be only a slight improvement over the original defect. Possibly it is better to



A



B

Fig 17—*A*, Loss of tip of nose presents a problem in surgical reconstruction in persons of advanced age. In this case restoration was carried out by utilizing a latex prosthesis. Cosmetic appearance (*B*) is satisfactory and the patient is satisfied.

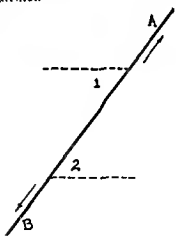


Fig 18

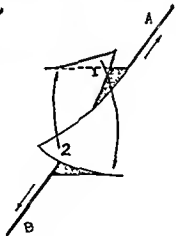


Fig 19

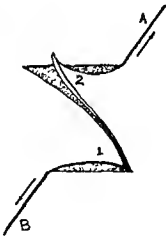


Fig 20

Fig 18—The most useful single procedure in plastic surgery is the Z plastic operation. Line *A B* represents the line of tension produced by scar tissue. The object of the operation is to introduce normal scar free tissue in this line of tension to impart elasticity to it. The broken lines, placed at an angle to line *A B*, in such a way as to form a Z are the principal components in outlining the desired operation.

Fig 19—With line *A-B* still representing the lines of tension flaps 1 and 2 are made by incisions along the previously determined lines. These flaps must be freely undermined in order to transpose them.

Fig 20—With the flaps 1 and 2 interchanged the position of the original Z is reversed, so that the line *A-B* has interposed in its line of pull two flaps of healthy, elastic tissue. This operation can be repeated along a line of tension if one operation does not give enough freedom.

have a facial prosthesis made for the defect. This would include such deformities as partial or entire loss of the nose and marked bony defects of the orbit and maxillary sinus (Fig 17 A and B).

There are numerous surgical procedures that will greatly improve functional and cosmetic results. The simple procedure of removing a wide and disfiguring scar and replacing it by a hairline scar will produce marked cosmetic improvement. This is done by adhering to the



Fig 21



Fig 22

Fig 21 Lacerations and contusions of the frontal area sustained in an automobile accident. The frontal bone was exposed but no fracture apparent. Patient seen with us 6 hours after the accident.

Fig 22 The wound was thoroughly cleansed, the roughened edges smoothed and the tissues undermined to give closure without undue tension. The hematoma just beyond the hair line was expressed manually and the laceration sutured. No drains were inserted. In addition to closing the wound by the method described in Figures 1 and 3 large pressure dressings were applied. It was felt that skin grafts were not indicated as a direct closure was possible.

physiological principle of reducing tissue tension to the minimum at the wound edges after the scar has been excised and the wound sufficiently undermined and properly sutured. Scars about the forehead, cheek and chin respond to this procedure with the most gratifying results. Linear contracting scars that cause disfiguring ectropion of the eyelids and lips and distortion of the external nares can often be corrected by a simple Z-plastic (Figures 18, 19 and 20 explain the principle of a Z-plastic operation). If the contracting scar is a broad

band, it may be excised and made into a linear one or replaced by a full thickness free graft or a pedicle graft

The use of autografts of cartilage or medullary bone in the reconstruction of bony contour of the nose, chin, forehead and cheek bone is becoming increasingly popular. Cartilage homografts have indicated usage under limited circumstances.

The problem of the proper management of facial injuries in all its aspects covers a broad expanse of surgical principles (Figs 21 and 22). Much emphasis must be placed on the axiom that there is only one chance we have to really help the patient and that is the first time he is seen. So much depends upon what is done at this time that it will determine to a large extent the post-traumatic morbidity. Early and proper treatment should be within the patient's reach even if several personalities must contribute to this end. The vast possibilities and the limitations in the field of surgical reconstruction should be made known to the patient with facial defects.

PEDICLE GRAFTS FROM THE ARM FOR RECONSTRUCTIONS ABOUT THE FACE

HILGER PERRY JENKINS, M D *

THE arm flap offers a simple and satisfactory means of restoring skin and subcutaneous tissue to defects about the face in selected cases. The four patients presented in this paper illustrate the usefulness of this procedure, the surgical technic involved and the vicissitudes inherent in these operations.



Fig 23



Fig 24

Fig 23 (Case I) —Showing original loss of tissue of frontal region shortly after propeller injury

Fig 24 (Case I) —Ulcerated scar tissue deformity five years after original injury

CASE I—A young woman received an injury five years previously from an airplane propeller which caused considerable loss of skin from the left side of her forehead and scalp loss of a fragment of temporal bone and damage to her left eyeball (Fig 23). Several attempts to skin graft the denuded area were made shortly after the injury. At the present time she has an unsightly scarred area on her forehead which is ulcerated in the central portion and around which there are irregular ridges (Fig 24). The base of the ulcerated area is apparently the periosteum of the frontal bone. All attempts to obtain healing thus far have failed.

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Operation—The arm flap was selected in preference to the free graft because of the chronic ulceration and infection in the scar and because of the desirability of having a thin layer of subcutaneous tissue between the bone and the skin.

The flap was prepared by a series of preliminary incisions which were made under local anesthesia using 0.5 novocaine. A cardboard pattern of the area that required grafting was cut out and used as a guide to determine the size of the pedicle on the arm. Parallel incisions were made, and the intervening skin and subcutaneous tissues were elevated from the underlying muscular fascia. These incisions were then closed with fine dermal sutures. After healing had occurred, these incisions were extended further upward, and an additional portion of skin was elevated from the fascia. After this was healed, a transverse incision was made at the upper end of these parallel incisions to interrupt the blood vessels entering this end of the pedicle. This was sutured and allowed to heal. In the next stage the entire pedicle was elevated from its bed by cutting through the previous incisions. This was done to determine the adequacy of the circulation through the distal end of the pedicle. The circulation did not appear to be satisfactory in the tip of the pedicle and so the flap was sutured back in place in its original bed instead of being transferred to the forehead at this time. A small area of necrosis developed at the tip of the pedicle.

When the small necrotic area had separated and healing had occurred, the flap was elevated again. This time the circulation appeared to be satisfactory, so the excision of the ulcerated scar tissue on the forehead was carried out and the flap was sutured into place with fine interrupted dermal sutures. The defect of the arm was closed by approximating the skin on either side of the pedicle with interrupted sutures. The arm was held in place by a plaster cast (Fig. 25). This operation was performed under so called "sterile" ether anesthesia.

The pedicle graft gradually became darker in color, and it was necessary to massage the flap gently to aid in eliminating the venous blood. This was done with cotton applicators at about half-hour intervals during the first night after operation. Without the aid of this gentle massage the pedicle would become very dark and cyanotic. The following morning the color of the pedicle was a bright pink, and the danger of necrosis appeared to be over. In addition to massage it is important to have the patient lay in such a way that gravity will aid in the elimination of the venous blood from the pedicle.

The pedicle graft healed in place on the forehead, and twelve days after the transfer, the base of the pedicle was compressed with a rubber covered intestinal clamp to determine the adequacy of the circulation from the new bed. There was no color change following the application of the clamp, so the base of the pedicle was cut across. The plaster jacket was removed, and the stump of the pedicle on the

arm was trimmed and sutured down. Two days later the free end of the pedicle on the forehead was trimmed and after excision of more of the scar tissue it was sutured in place. There was considerable redness and swelling of the flap on the following day which was especially noticeable at the place where it was most recently sutured into place. It was necessary to remove several of the sutures and evacuate a moderate collection of purulent material which had collected under this part of the flap. A heavy growth of hemolytic *Staphylococcus aureus* was obtained on culture. Following this the healing progressed without mishap.



Fig 25



Fig 26

Fig 25 (Case I) —Pedicle graft from arm sutured in place on forehead after excision of unsightly ulcerated scar. Immobilization obtained by body and arm cast.

Fig 26 (Case I) —End result of arm flap transferred to forehead fifteen months later.

For several months after the transfer of the flap to the forehead there was some fullness of the graft which was not entirely desirable. This improved over a period of months until the flap was smooth and had merged with the surrounding skin without a conspicuous line of junction. At fifteen months the end result was quite satisfactory (Fig 26). The artful use of cosmetics has minimized any appreciable difference in color which is of course to be expected when arm flaps are used about the face. When last seen six years after the operative procedures described the graft was in good condition.

CASE II —A woman aged 60 years first noticed a red scaly indurated lesion on her cheeks forty five years ago. This was diagnosed as lupus vulgaris. During the following seven years she had several series of x ray treatments for the lesion. On one occasion the patient was inclined to believe that a very considerable

overexposure to the x ray occurred as the result of an oversight on the part of the x ray attendant. Subsequently there was increased redness of the lesion. Ulceration later developed involving the nose. A pedicle graft from the arm was used to reconstruct the nose. This was performed twenty years ago. In the past three years she has noticed an ulcerated lesion on the left side of her cheek which has progressed until it has partially destroyed the left side of the reconstructed nose and the upper lip (fig. 22). Repeated biopsies of this lesion failed to reveal a malignant lesion. The dermatology consultants believed that the lesion represented a late result of an old lupus vulgaris complicated by actinomycetosis from x ray. The right side of the reconstructed nose was in good condition and the right cheek was free from ulceration.

Operation—A pedicle flap from the arm was planned which would be adequate to restore the upper lip, the side of the nose and part of the cheek. This was mapped out on the arm and preliminary preparatory incisions were made. This was done in two stages. Parallel incisions were made, the intervening skin was elevated and then the incisions closed. The upper end of the pedicle was transected ten days later and sutured.

After another two weeks the entire pedicle was elevated and found to have adequate circulation. The defect on the arm was partially closed with interrupted sutures and the remaining raw surface was covered by a sulfathiazole ointment dressing. The lesion on the cheek, side of the nose and lip was then excised. The pedicle graft was cut in such a way that part of the graft formed a flap for the upper lip and the other part formed a flap for the restoration of the left side of the nose. The remainder of the flap was used on the cheek. The arm was immobilized in a plaster cast as described in the previous case.

The microscopic examination of the tissue removed at operation revealed basal cell carcinoma. It is difficult to explain why the many previous microscopic examinations of tissue removed from this lesion failed to reveal the presence of the carcinoma.

When the pedicle graft had been in place for ten days the base of the pedicle was constricted by a rubber tourniquet. No appreciable color change occurred so the base of the pedicle was transected, the cast removed and the stumps of the pedicle dressed with sulfathiazole ointment dressings. Two days later the remaining raw surface on the arm was covered by a dermatome skin graft. The remaining pedicle on the cheek was then trimmed, more of the skin of the cheek was excised and the pedicle graft was sutured into place. Satisfactory healing occurred.

When the result of the pedicle graft was reviewed a month later it was apparent that there was more subcutaneous tissue under the lateral portion of the flap than was cosmetically desirable. This was the last portion of the flap to be sutured in place after the transection of the base of the pedicle. There is some risk of impairing the circulation of this portion of the flap by endeavoring to thin out the subcutaneous tissue to any great extent soon after the pedicle is severed.

from the arm. It is preferable to thin out the subcutaneous tissue at a subsequent operation when the tissues are less indurated and the blood supply less vulnerable. This was done for the patient at this time and considerable improvement resulted.

After another three months an additional procedure was performed to improve the appearance of the nose at its junction with the cheek. An incision was made along the left side of the reconstructed nose and a considerable amount of subcutaneous fat excised. The incision was closed and pressure applied along the incision with a dressing in such a way that the crease at the junction of the nose and cheek was restored.



Fig 27

Fig 28

Fig 27 (Case II)—Destructive ulcerating lesion involving lip, cheek and side of reconstructed nose. This was found to be basal cell carcinoma which had developed in an area which had been damaged by excessive x-ray treatments for what originally was believed to be a lupus.

Fig 28 (Case II)—End result at seven months of pedicle graft from arm to restore upper lip, side of nose and cheek after excision of basal cell carcinoma.

After another two months the end result was reviewed again and it was found that there was too much fatty tissue on the right side of the nose, which had been reconstructed twenty years previously to match the result obtained on the left side. This was thinned out by an incision made on the right side of the nose at the junction with the cheek. After this was healed the end result appeared to be reasonably satisfactory (Fig 28).

CASE III—A 33 year old woman had a vascular nevus involving most of the right side of her face since birth. She received a number of carbon dioxide snow treatments when she was about 5 years old. When she was 17 years old she re-

ceived radium treatments about once a month for the next two years. After these treatments the port-wine color of the lesion was somewhat lighter, but the surface became more irregular. At the age of 18 an ulcerated area developed on the nose. This was diagnosed as a "malignant lesion," and intensive radium treatments to this area were resumed. The lesion healed over and did not cause trouble for ten years. In the past year an ulcerated lesion again developed on the nose and failed to heal.

Examination reveals extensive right-sided vascular nevus and actinodermatitis, which is most severe on the skin of the cheek and the side of nose. An ulceration is present on the nose which extends into the nasal cavity (Fig. 29).



Fig. 29 (Case III).—Extensive vascular nevus of face, and actinodermatitis from extensive radium treatments. Area of necrosis has developed on nose with perforation into nasal cavity. The skin about the perforation and on part of cheek shows severe damage from the radium and may undergo malignant degeneration.

Operation.—The margins of the ulcerated lesion were excised, and an attempt was made to close the skin over the defect. The microscopic examination of the tissue removed did not reveal evidence of malignant changes. The wound did not heal, and another ulceration developed. There was some evidence of necrosis of the tip of the nasal bone which could be seen in the depth of the ulcerated lesion.

The perforation into the nasal cavity would of course necessitate a pedicle graft. The area of skin on the cheek which was most severely damaged by the radium would require replacement because of the possibility of subsequent carcinomatous degeneration. One had the choice of a small flap just for the nose and a dermatome graft for the

cheek or of a larger flap which could be used for both nose and cheek. The latter method was chosen.

Preliminary incisions in two stages were made in the arm, as described in the previous case. When these were healed, the flap was elevated from the arm and the donor bed closed by sutures. The flap appeared to be entirely viable, so the most severely damaged skin of the nose and cheek was excised and the flap sutured into place. The arm was immobilized in a plaster cast (Fig. 30). The portion of the pedicle between the cheek and the arm was formed into a tube by approximating the edges with sutures. This obliterated the raw surface



Fig. 30 (Case III) —Pedicle graft from arm to nose and cheek. Rubber tourniquet has been applied to base of pedicle to test adequacy of new circulation before cutting base of pedicle.

which is otherwise obtained in this type of graft. Ten days later the base of the pedicle was transected after being tested with a tourniquet for adequacy of the new circulation.

Four days after the transection of the base of the pedicle, the tubed portion of the pedicle attached to the cheek was unfolded and trimmed. An additional area of the cheek skin was excised and the graft was sutured down in place. In reviewing the immediate result of the graft it was observed that there was more subcutaneous fatty tissue under the graft than was desirable (Fig. 31).

After three secondary procedures on the graft during the ensuing five months, the excess subcutaneous tissue was removed without im-

pairing the circulation to the graft. When the result was reviewed one year after the transfer of the graft to the face the cosmetic result appeared to be satisfactory (Fig. 32). The patient had become quite adept at the use of 'covermark' which was necessary to conceal the remaining portion of the vascular nevus and also served to make a satisfactory color matching of the pedicle flap which otherwise would have a lighter color than the normal skin of the face.

There was some question about removing more of the skin involved by the vascular nevus. The remaining areas did not show evidence of



Fig. 31



Fig. 32

Fig. 31 (Case III) —Immediate result of pedicle graft to nose and cheek to restore skin to the area which had been most severely damaged by the radium and which may otherwise undergo malignant change. At this time there is more subcutaneous tissue under the flap than is cosmetically desirable.

Fig. 32 (Case III) —End result of pedicle graft to nose and cheek. Subcutaneous tissue under flap has been thinned out and 'covermark' used to conceal the remaining vascular nevus and to make a satisfactory color matching of the pedicle graft.

precancerous changes as a result of the radium treatments and in view of the satisfactory cosmetic result obtained by the covermark there was neither a medical nor cosmetic indication to replace the rest of the skin involved by the nevus.

CASE IV —A man aged 46 years received an extensive series of x-ray treatments on his face about fifteen years previously. This was done for a pustular dermatitis. A severe actinodermatitis developed and during the past three years he had noticed multiple lesions developing on the skin of his face and nose. Crusts formed over these lesions and when these were removed an ulcerated

area would remain. There was one relatively large lesion involving the tip of the nose. This lesion was excised and found to be squamous cell carcinoma. The situation required an extensive program of skin excision and replacement not only of the nose but of the entire face from beneath the eyes to below the chin. The details of this program of skin replacement are described elsewhere² and in this report we are concerned only with the reconstruction of the nose (Fig 33).

Operation—A pedicle graft from the arm was planned and prepared by preliminary incisions which were allowed to heal (Fig 34). The



Fig 33



Fig 34

Fig 33 (Case IV)—Actinodermatitis of face from x ray treatment fifteen years previously and multiple areas of squamous cell carcinoma which have developed in past three years. Lesion on tip of nose recently removed.

Fig 34 (Case IV)—Preliminary incisions in arm in preparation of pedicle graft for transfer to nose. The parallel incisions were made first and the intervening skin elevated and then the incisions sutured. The upper end of the flap was subsequently cut across, sutured and allowed to heal. The flap is now ready to be elevated in its entirety and the circulation will be adequate from its distal attachment to arm.

flap was then elevated and the defect closed by interrupted sutures except at the base of the pedicle. The rest of the skin of the nose was excised, and the pedicle was sutured into place on the nose (Fig 35).

There is one technical point that deserves mention and that is the difficulty that developed as a result of closing the defect on the arm too tightly after elevating the pedicle and transferring it to the nose. There was so much constriction of the arm from the tight closure

that it acted as a constrictor of the arm and impaired the return circulation of the pedicle graft and the arm. The flap became progressively more cyanotic, and massage did not improve the appearance. It was necessary to remove the sutures which closed the skin over the donor bed. As soon as this was done, the return circulation improved, and it was possible to keep the graft in a satisfactory condition without further cyanosis by occasional gentle massage.



Fig. 35



Fig. 36.

Fig. 35 (Case IV).—Pedicle graft from arm transferred to nose and arm immobilized in plaster cast. The base of the pedicle can now be transected as the establishment of the circulation from the recipient bed is adequate at end of ten days as determined by applying rubber tourniquet to base of pedicle.

Fig. 36 (Case IV).—End result of nasal reconstruction with flap from arm. In addition, large dermatome grafts have been used to replace all of the skin of the face from below the eyes to beneath the chin, to eliminate multiple areas of squamous cell carcinoma developing in areas of actinodermatitis from previous x-ray treatments.

After thirteen days the base of the pedicle was transected, and the free end of the detached pedicle on the nose was trimmed and molded into shape to produce the nasal tip, columella and alae. This healed and the cosmetic result was satisfactory (Fig. 36).

COMMENT

In the preparation of the pedicle grafts from the arm, the procedures described permit the establishment of adequate circulation in

the flap, without leaving the tissues open at any time. The advantage is that the flap does not shrink in size as it usually does if tension is not maintained on the flap during the course of preparation. Also infection is avoided.

When a pedicle is elevated from the arm, one has a choice of having the circulation pass through either the proximal or the distal portion of it. For some of the places about the face and head it is preferable to have the pedicle severed at its proximal end and attached by its distal end. This avoids having the pedicle completely rotated at its base, as would otherwise be necessary for these regions. With reasonable care any disadvantage of using the distal attachment for the base of the pedicle can be overcome, and better results can be obtained.

When a pedicle is elevated from the arm and the circulation does not appear to be entirely satisfactory throughout the pedicle, it is better to suture the flap back in place in its own bed and allow more time for adequate circulation to be established in the flap before transferring it to the recipient site.³ This procedure, which was necessary in the first case, may save a considerable portion of the pedicle, which otherwise may undergo necrosis if transferred at a time when the circulation is not entirely satisfactory.

When the pedicle is transferred to the recipient area and the arm is immobilized in a cast, considerable care should be taken to have the patient maintained in bed in such a way that the pedicle does not assume a dependent position, as this will not favor the return circulation which is often somewhat impaired for the first twenty-four hours. In addition, it may be necessary to massage the pedicle gently until the venous return is satisfactory. This procedure was necessary in the first, third and fourth cases, and it is possible that a complete necrosis of the pedicle would have occurred without it. The massage was carried out by cotton applicators which were soaked in an antiseptic solution (S.T. 37) and gently rolled across the pedicle. A pressure dressing would aid in preventing venous stagnation, however, there is considerably more satisfaction in being able to observe the state of the circulation at all times rather than depending entirely on the pressure dressing to avoid the venous stagnation.

Care should be taken in the closure of the skin of the arm after elevating the pedicle to avoid a constrictor effect on the arm and an impairment of the return flow of blood from the pedicle and the arm, especially when the base of the pedicle is the distal attachment. In the fourth case, so much constriction was obtained by the complete closure of the defect of the arm that the circulation in the pedicle was severely embarrassed. After removal of the sutures in the arm, the circulation was quite satisfactory.

It is preferable to approximate the skin edges to some extent so that there is not a wide gaping raw surface. A free graft would generally suffice to close most of these defects and it is possible that putting the

graft is at the time that the pedicle is elevated would be the wisest procedure. The time for the establishment of adequate circulation from the recipient bed generally varies from ten to twelve days, at which time the base of the pedicle may be transected. It is preferable to test the adequacy of the circulation by constricting the base of the pedicle with a small rubber tourniquet before transecting the base.

It is desirable to allow a short interval of one or two days after the transection of the pedicle before trimming and suturing down the portion of the pedicle in proximity to the line of transection. This permits a little better circulatory adjustment of this portion of the flap and insures its complete viability when sutured down into the defect.

Secondary revisions of the graft to obtain the best cosmetic effect may be carried out at a later date without great danger to the viability of the graft, until one is entirely satisfied with the end result. However, if one endeavors to thin out subcutaneous tissue too much at the time the graft is transferred from the arm to its recipient site, there is an increased danger of necrosis of a portion of the flap. In two of the cases which were presented it was necessary to make several secondary revisions of the graft to obtain the desired result.

In the use of *chemotherapeutic agents*, penicillin is desirable while the pedicle is being transferred and after the flap has been entirely sutured down on the recipient bed. A very trivial infection may seriously impair the healing and the ultimate cosmetic result, and since penicillin has become generally available, its use is warranted as an additional safeguard.

For the type of 'delayed' flap which is prepared by preliminary incisions that are allowed to heal the length of the flap elevated at any one time should be about twice the width. There is a margin of safety of about 25 per cent or more to this general rule. This is probably the safest rule to follow for the flaps that depend on the distal attachment for blood supply, although the flaps that have their blood supply from the proximal end probably can be made somewhat longer in proportion to width.

A cardboard pattern of the defect for which the pedicle graft is planned is of considerable assistance to the surgeon. The pattern may be placed on the arm and an attempt made to elevate it to the defect. This helps him to decide whether the proximal or distal attachment should be severed and elevated up to the defect, and also aids in determining the most desirable location for the flap from the arm so that the preliminary incisions can be correctly placed to give the best results. This was used in the cases presented.

The arm flap for reconstructions about the face has a field of usefulness in selected cases. The chief disadvantage is the color matching. For women this is not much of a disadvantage, as cosmetics and 'covermark' can usually suffice. The permanent pigment injection

described by Hance, Brown, Byars and McDowell⁴ appears to offer a satisfactory method of color matching which would be especially suited for men

In addition to free grafts⁵ there are several other grafts that may be used for work about the face, such as the forehead flap, the scalp flap, sliding flaps from the neck and tubed pedicles from the neck. The procedure for any one case should be worked out as an individual problem. The cases presented were selected to illustrate some of the uses of the arm flap which were found to be satisfactory for these particular problems

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THE REPAIR OF SKULL DEFECTS WITH SPECIAL REFERENCE TO THE USE OF TANTALUM

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INTRODUCTION

CRANIOPLASTY has a long history. Although the literature on the repair of cranial defects extends back to 1600, success must have been extremely rare before the development of aseptic surgery. Bone grafts from other species and a wide variety of metals as well as other alloplastic substances have been used at various times. Woolf and Walker have currently reviewed the subject thoroughly and the reader is referred to their excellent paper.

The writer's experience with cranioplasty over the past decade includes the recent period of renewed interest in the use of alloplastic materials for the repair of skull defects. When Grant and Norcross wrote their excellent paper in 1939 that presented eighty-three cases, they condemned the use of alloplastic materials of all types. They advocated the use of periosteal outer table grafts for defects smaller than 6 by 6 cm., and for larger defects they advocated split-rib grafts. This authoritative paper seemed to be the final word on the subject but interest in alloplastic grafts was soon to be revived with reports from the orthopedic field on the newer alloys and metals.

Geib in 1941 reported the use of vitallium in the repair of skull defects, and other reports by Beck, Peyton and Hall, and Lipscomb and Groves soon appeared. However, this alloy while apparently inert in the tissues had to be cast to fit the defect.

Tantalum was meanwhile being investigated by Pudenz and Odom for its effect on the brain and meninges and they reported minimal connective tissue or glial response. Since it is malleable and ductile its advantages for cranioplasty were apparent. Fulcher was apparently the first to use tantalum for the repair of a skull defect in a clinical case. He carried this out on November 24, 1941, on a submarine fireman. The entrance of this country into the war shortly after that made the repair of cranial defects an important subject. The attitude of the medical departments of the armed forces was uniform and dictated that all but the smallest defects be repaired as a matter of routine. In both services tantalum was given preference and the tantalum available for surgical use was earmarked for the use of the armed forces. How-

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ever, greatly increased production has since made it generally available

INDICATIONS FOR CRANIOPLASTY

In view of the general accord in the literature on the indications for the repair of cranial defects and the general anxiety on the part of the layman about them, it is surprising that so many patients in the past have been allowed to keep unrepaired defects. However, knowledge of the technical difficulties and of the numerous failures in the past has usually deterred all but the neurologic surgeon from other than sporadic attempts at these repairs. The neurologic surgeon with his wide experience with therapeutic decompressions is often subconsciously, if not consciously, contemptuous of the fear of the patient or his relatives about a skull defect and therefore inclined to discourage the procedure unless the patient insists upon it.

The important reasons for repair of a skull defect include local pain or tenderness about the defect, the syndrome of the trephined, unsightliness of the defect, undue pulsation or pain, protection from trauma, military or economic reasons, anxiety of the patient or psychogenic states and epilepsy (Grant and Norcross, Mayfield and Levitch, Woolf and Walker).

Local Pain and Tenderness—On occasion the scalp about the margin of a skull defect is very tender. This may be so severe at times as to render the slightest pressure or manipulation very painful. It may be seen with either protrusion of the intracranial contents or depression of the scalp over the defect. It is frequently associated with the small (1 cm.) operative defects that are made for the purpose of ventriculography. It is apparently a neuritis of the cutaneous nerves of the scalp and may be related to the scar in the scalp or to stretching of the scalp over the defect. Its presence in a marked degree constitutes an indication for cranioplasty.

Syndrome of the Trephined—This includes the complaints of headache and dizziness, especially with sudden posture changes. Easy fatigue, irritability and lack of ability to concentrate may be associated with this. Subjective dizziness with postural change is usually seen for a few weeks after a cranial injury or operation and the whole syndrome is not uncommon after cases of head trauma where it is often labeled the post-traumatic syndrome. It is thought to be due to a temporary instability in the cerebral vascular alterations normally associated with postural change of the head. In the presence of a cranial defect these symptoms may be aggravated and their persistence facilitated. In the author's experience it is not as common as the literature would lead one to believe. Since the syndrome is in part at least psychogenic, repair of the skull defect may not cure the patient. However, perhaps for psychogenic reasons, it usually alleviates the symptoms if it does not entirely clear them up.

Unsuitableness of the Defect—Cosmetic reasons are a frequent indication for cranioplasty. All frontal defects below the hairline fall in this category as do many defects within the hairline in males. A large skull defect can be concealed satisfactorily by the hair only in woman. The same justification can be advanced for cranioplasty for cosmetic reasons as for any other type of cosmetic surgery. Extensive scarring of the forehead or loss of the supraorbital ridge may complicate the procedure. In the former case the cooperation of a plastic surgeon is desirable.

Undue Pulsation or Pain—Unusually marked pulsation of a cranial defect not only may contribute to the patient's discomfort but also to the unsightliness of the defect. It is more likely to occur in large than in small defects. Pulsations of the intracranial contents is a pathological phenomenon only seen in the presence of a skull defect. Gardner has recently emphasized this and discussed its possible implications particularly with reference to the development of epilepsy. He considers any pulsating defect deleterious and an indication for repair of the defect. This opinion has not been generally accepted but perhaps deserves further consideration.

Military or Economic Reasons—Military reasons have and are dictating the repair of large numbers of cranial defects. Army regulations (Woolf and Walker) state that a soldier cannot be sent back to active duty with a skull defect larger than 2 cm. In civilian life in normal times many employers refused to accept a man for employment who exhibited a skull defect. In many cases repair of a skull defect is as necessary for economic rehabilitation of a patient as repair of an inguinal hernia.

Anxiety or Psychogenic States—The average layman and many physicians ascribe undue significance to a skull defect. Consequently many patients are so concerned about their skull defect that they develop marked anxiety with great concern about any subjective symptoms referable to the defect. Patients with unstable or inadequate personalities may develop a severe psychoneurosis which may be cured or greatly improved by cranioplasty. Some psychoneurotic individuals with marked functional disturbances following cerebral trauma with an associated skull defect may be benefited by repair of the defect. However unless care is exercised in the selection of these cases disappointment in the results may occur.

Epilepsy—This has been stated by various authors to be an indication for repair of a skull defect. It is highly improbable that plastic repair of a skull defect alone permanently helps a case of post-traumatic epilepsy. Patients who have epilepsy and on whom repair of a skull defect is indicated for one of the foregoing reasons should be carefully evaluated for indications for the surgical removal of a possible epileptogenic lesion (Voris). If such a procedure is indicated it should be combined with the cranioplasty. Conversely, the patient

with epilepsy and a skull defect on whom a surgical attack on an epileptogenic lesion is carried out, should have a simultaneous repair of his skull defect. However, epilepsy alone is an insufficient indication for repair of a skull defect.

CONTRAINDICATIONS TO CRANIOPLASTY

Grant and Norcross and Woolf and Walker have listed various contraindications.

Infection or Contamination of the Wound—This is the most important contraindication. Success with any of the various techniques of cranioplasty cannot be expected in contaminated or infected wounds. Formerly there was general agreement that cranioplasty should not be carried out in fresh compound wounds and that if infection followed the original wound or operation it should be postponed until several months after the wound had completely healed. The recent developments in chemotherapy and the fact that tantalum in itself shows little or no tissue reaction undoubtedly makes it possible to reduce this period of waiting from several months to a few weeks. Unfortunately, perhaps due to a laudable desire to return soldiers to active duty as soon as possible, certain neurologic surgeons, especially in the armed forces, have advocated and carried out the placement of tantalum plates in contaminated compound or even grossly infected wounds. Some successes have undoubtedly occurred but there is great risk of failure. The writer has personal knowledge of several unreported cases in which tantalum plates have been removed because of persistent sinuses or of failure of the wound to heal. Undoubtedly many other such cases have and will occur. The advantage of chemotherapy and of noncytotoxic metals should not entice the surgeon into disregard of fundamental surgical principles. Cranioplasty has no place in the immediate surgical management of compound wounds of the head or of infected wounds. It should be postponed for at least a few weeks after complete wound healing has taken place and all external evidence of tissue reaction has disappeared.

Cerebrospinal Fluid Abnormalities—Pathogenic changes in the cerebrospinal fluid such as increased pressure, increased cell count or total protein, point to residual inflammation such as abscess or to the presence of some other space-occupying lesion. Obviously increase in intracranial pressure as evidenced by bulging of the scalp over the defect or by papilledema is a contraindication to cranioplasty.

Foreign bodies retained within the cranial cavity have generally been considered a contraindication to cranioplasty. Small metallic foreign bodies that have been present for some time with no evidence of abscess or meningitis would not seem to contraindicate the repair of a cranial defect. However, either diagnostic air studies or observation over several months should rule out the possibility of an abscess before cranioplasty is indicated.

Neurologic Disability—Severe neurologic disability, such as hemiplegia, obviously is a contraindication to cranioplasty. The object of a plastic procedure is to restore an individual to normal. If severe disability is present, restoration to normal is obviously impossible and there is no reason for cranioplasty.

TECHNIC OF CRANIOPLASTY

There is a wide choice of materials for cranioplasty. Bone from adjacent areas of the patient's skull may be used or bone or cartilage may be obtained from other portions of his body (autogenous grafts). Material from another human being (homogenous grafts), from other species of animals (heterogenous), or various metals or organic or inorganic materials (alloplastic grafts) may be used. The author's experience has been entirely with autogenous or alloplastic grafts.

Periosteal Outer Table Grafts—The original Mueller-Koenig method of flap transposition has been widely modified and improved. Some modification of it has been in the past the most widely used and satisfactory method of cranioplasty. Its advantages are that no operative procedure is necessary on other parts of the patient's body and that there is a very high percentage of success. The disadvantages are that it is unsatisfactory for large defects especially in the frontal region because of its lack of rigidity. Further, in large defects very extensive scalp incisions are necessary as not only must the bony defect be adequately exposed but also an equally large donor area of adjacent skull. Defects involving the supraorbital ridge cannot be satisfactorily repaired by this method. It remained however, as Grant and Norcross emphasized, the most satisfactory method of cranioplasty until the recent development of the newer noncytotoxic metals.

In this method a scalp flap of sufficient size to expose the skull defect and an equal donor area is reflected. The periosteum is incised along the edge of the defect and removed from its margin which should be freshened with rongeurs. Next an exact pattern of the defect is cut from sterile x ray film. The pattern is then laid on the donor area and the periosteum is incised along a line parallel to the pattern, but about 5 mm outside of it. The periosteum is then elevated for 5 mm around the entire graft and then the outer table is elevated with a chisel, making this portion of the graft the same size as the original pattern. Care should be taken not to separate the periosteum from the outer table. If the graft is large it may not be possible to elevate it in one piece. However, with care this can usually be done. In any case the graft, after elevation, should comprise one or more pieces of outer table attached to the overlying periosteum which extends for 5 mm beyond the margin of the bone graft. When the donor area extends into the temporal region, care is necessary to prevent elevation of the entire thickness of the skull with consequent production of a new defect.

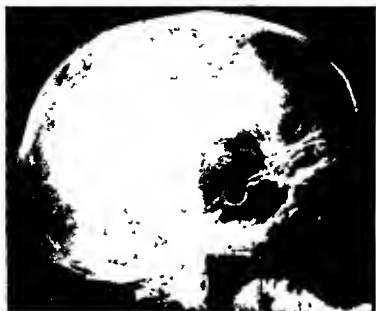


Fig 37 (Case I) —Postoperative defect in temporal region Lateral view



Fig 38 (Case I) —Postoperative defect in temporal region after repair with periosteal outer table graft Lateral view

The graft is put into position over the defect and fixed by multiple silk sutures through the periosteum of the graft and that of the skull

The scalp wound is closed without drainage. Hemostasis of the bone in the donor area can be accomplished by the use of bone wax. If blood or serum collects beneath the scalp postoperatively it may be removed by aspiration.

CASE I—C. M., a 37 year old white man had been operated on eighteen months before for middle meningeal hemorrhage and had a large bony defect in the left temporal region (Fig. 37). He complained of constant left temporal pain with local tenderness about the edges of the defect and he would not return to his work as a telephone lineman. The operative area bulged slightly when he laid down but was excessively depressed when he was erect. When finally operative repair of the defect was suggested he accepted it at once. The original vertical incision in the temporal region was curved forward so as to expose a donor area on the left frontal bone. The operative defect was found to measure 6 by 4.5 cm. after its edges were freshened with rongeurs. The technique described above was followed exactly except that the inferior part of the graft was anchored in the bony defect by suturing its edges to the adjacent temporal muscle instead of to the periosteum.

Convalescence was uneventful. Figure 38 shows the result from a roentgenographic standpoint. The patient's local pain and tenderness were relieved and there was no longer any effect of postural change on the operative site. He returned to work two and one half months after operation although he continued to complain of paresthesias in the left cheek.

Comment—This was a satisfactory result. Although the defect was fairly large it was so situated that exposure of a donor area was not difficult. Since the graft was largely covered by temporal muscle any possible lack of rigidity was not noted.

CASE II—L. M., a 25 year old man received a severe compound head injury in the right temporal region sixteen months before. There was a horizontal 18 cm. scar about 5 cm. above the ear extending from above the right eye to the occipital region. X rays showed a large bony defect above this which extended anterior to the hairline and up across the midline. There were two detached fragments of bone. No evidence of osteomyelitis was seen. The patient wished the defect repaired for cosmetic reasons.

A very large scalp flap was reflected with its base in the left parietal region. The anterior limb of the incision paralleled the anterior margin of the defect; its convexity included the anterior part of the original laceration and the posterior limb extended back across the vertex to the left side. The two loose fragments of bone were anchored into place on the left side of the defect with silk sutures passed through gimlet holes in the bone edges. Then a patterned periosteal outer table graft was cut from the right superior parietal region. There was some difficulty because of the large size of the graft but a satisfactory graft was finally obtained and anchored in the defect in the usual way.

The patient made a good convalescence and left the hospital eight days later returning to work a month after the operation. However he has been dissatisfied with the results of the graft. Its lack of rigidity allowed it to sink in somewhat, especially in the anterior part of the defect anterior to the hairline.

Comment—This was not a suitable case for a periosteal outer table graft. It was carried out before the writer began to use alloplastic grafts but the use of split rib grafts would have been much more satisfactory for a defect of this size, especially one that extended below the

hairline This patient has since been offered repair with a tantalum plate but to date has not accepted this

Rib Grafts (Autogenous Grafts)—Bone from a variety of other sources such as rib, tibia, ilium, scapula and sternum has been used by surgeons to repair cranial defects (Woolf and Walker) Many have used rib grafts The curve of the rib readily adapts it to the contour of the skull and by splitting the rib additional graft material is obtained Only in extremely large defects would more than two segments of rib before splitting be necessary Many authors have used rib cartilage for repair of skull defects It presents no advantage over rib except in the repair of supraorbital ridge Here the fact that it can be carved with a knife makes it possible to sculpture it readily to the desired contour

When this method is used two operating teams, one to obtain the graft, the other to repair the defect, are helpful If the work is to be done by one team, the graft should be obtained first The defect should be carefully measured before the operation Any rib may be taken but the writer prefers the right seventh, or seventh and eighth An incision is made over the seventh rib beginning at the anterior axillary line and extending posteriorly for the desired length A segment is resected subperiosteally beginning at the costochondral junction and extending posteriorly as far as desired If two segments of rib are necessary, they may, if not too long, be obtained from the seventh rib or by retraction the eighth rib can be exposed and a suitable segment obtained from that If the defect involves the supraorbital ridge and cartilage is desired, the skin incision can be extended anteriorly to expose the rib cartilage which can then be obtained in the desired amount The grafts are then laid aside in sterile gauze moistened with normal saline solution and the incision is closed

Now the operators change gowns and gloves and the cranial field is prepared and properly draped Adequate exposure of the defect is of course necessary Usually the previous scalp incision or wound is used, enlarging it as may be necessary for adequate exposure The defect is prepared as for a periosteal outer table graft If the rib graft or grafts require splitting, this is done with a chisel or saw and then they are trimmed to fit into the defect They must be anchored with silk or wire sutures passed through drill holes in their edges and the adjoining bone edge The scalp is then closed without drainage

This method is much superior to the periosteal outer table graft for large defects and for defects involving the supraorbital ridge Seldom do the patients complain after operation about their chests In the frontal region the slight irregularity of the graft due to the small depressions between the pieces may be noticeable Above the hairline this is of course not important The principal disadvantage of the method is the necessity for an operative procedure on the chest wall This lengthens the operation considerably unless two operating teams

are used. If the patient is obese, obtaining the graft is more than usually difficult. In many respects rib grafts appear superior to grafts from other bones. The removal of large grafts from the tibia or ilium may seriously weaken these bones and the patient may complain of discomfort in the donor area for a long time afterward.

CASE III—A M., a 47 year old colored woman had a left superior parietal osteoplastic craniotomy with removal of the bone two years before (Fig. 39). She complained bitterly of pain and paresthesias in the operative region and had a great fear of being struck on her "soft spot." Because of this often reiterated fear and the persistence of the local tenderness, pain and paresthesias in the operative region she was offered plastic repair of the defect.



Fig. 39 (Case III)—Postoperative parietal skull defect. Lateral view.

The initial stage was carried out with the patient in the prone position. An incision was made over the right seventh rib posteriorly. The sixth and seventh ribs were exposed by retraction and an 8 cm. segment of each was resected subperiosteally. This was somewhat difficult because of the marked obesity of the patient. The wound was closed and the patient placed on her back. The former scalp flap was reflected in the left posterior parietal region. The defect was exposed and its edges freshened with rongeurs. The two segments of rib were split longitudinally and the resultant four strips of bone were trimmed to fit vertically into the defect side by side. They were anchored with silk sutures passed through drill holes in their ends and the bone edges. The scalp was then closed without drainage. Recovery was prompt. The collection of fluid beneath the scalp necessitated aspiration on two occasions, but the wound healed by primary intention. Figure 40 shows an x-ray taken before dismissal from the hospital. The patient was well pleased with the result and no longer complained of any discomfort in the operative region.

Fifteen months later another roentgenogram revealed almost complete absorption of the rib segments. However the region of the former defect was firm and

solid to palpation. The absorption of autogenous bone grafts from other sources than the skull itself has been reported by Gurdjian and others. However, such absorption when it occurs does not cause an unsatisfactory result. As the graft absorbs it is replaced by a plate of firm fibrous tissue which is entirely satisfactory to both patient and surgeon.

Comment—This was an entirely satisfactory result. The defect though large was entirely within the hairline and was adequately covered by the patient's hair. However, the patient's fear and her



Fig. 40 (Case III)—Postoperative parietal skull defect after repair with split rib grafts. Lateral view.

subjective complaints necessitated its repair. The rib grafts were a little difficult to obtain because of the patient's obesity but were the best available means of repairing this defect at that time.

CASE IV—F. O., an 18-year-old boy, suffered a severe head injury with a compound depressed fracture of the right frontal bone two years before. Five months later another neurologic surgeon had removed the depressed bone fragments. The patient's only complaint was of the cosmetic defect and he requested repair for that reason. His defect included part of the right supraorbital ridge and extended

rib and rib cartilage graft was used. Operation was carried out on May 17, 1944. The initial step was removal of a 10 cm. segment of the right sixth rib and its cartilage. After the chest wound had been closed the former scalp incision was reopened and the bony defect exposed. This defect was triangular in shape extending upward and backward for about 8 cm. with its base including about 5 cm. of the supraorbital ridge. After the usual exposure and freshening of the bone



Fig 41 (Case IV) —Post traumatic skull defect Lateral view



Fig 42 (Case IV) —Post traumatic skull defect one year after repair with split rib graft Lateral view

edges a piece of rib and rib cartilage was fitted into the base of the defect, re-constructing the supraorbital ridge as accurately as possible. The remainder of the defect was filled in with two smaller pieces of rib. These pieces were placed

vertically with their ends against the horizontal piece that formed the new supra orbital ridge. The grafts were anchored by silk sutures passed through holes drilled in them and in the adjacent bone edges. They were also tied to each other by similar sutures. The medial part of the defect involved the frontal sinus. The scalp was closed without drainage. Convalescence was uneventful and the patient left the hospital eight days later.

The patient has been satisfied with the cosmetic result although the scar is

Comment.—This result was fairly satisfactory. The irregularity of rib grafts makes an imperfect cosmetic result in defects below the hairline. However, a very satisfactory reconstruction of the supra-



Fig. 41 (Case V).—Partially decalcified autogenous boiled bone graft four months after placement. Anteroposterior view.

orbital ridge was achieved and the patient was well satisfied with the result. This defect could not have been satisfactorily repaired with a periosteal outer table graft because of its size and of the involvement of the supraorbital ridge.

Boiled Bone Grafts (Autogenous or Homogenous).—Several authors, including Pankratiev, Nassziger and Gurdjian, have reported the use of boiled bone, either obtained at autopsy or from the patient's own skull, for the repair of skull defects. Such grafts while technically homogenous or autogenous are in reality foreign bodies. Gurdjian reported the absorption of the graft in such cases and the writer's experience substantiates this. Their greatest use is in those cases of

invasion of bone by tumor Here boiling of the involved bone and replacement of it at the primary operation obviates its sacrifice with a resultant skull defect Such a procedure requires less time than the fashioning and fitting of a tantalum plate and is perfectly satisfactory from a cosmetic standpoint The graft will be slowly absorbed but will be replaced by a plate of firm fibrous tissue that will be equally satisfactory from a cosmetic standpoint

CASE V—G C., a 22 year old man, was operated on because of a midline osteoma above the external occipital protuberance The tumor was exposed by reflection of a horseshoe shaped scalp flap with its base posteriorly It was removed en bloc by connecting several burr holes around its periphery with the Gigli saw Bleeding from the dura and the longitudinal sinus was controlled with several small pledgets of muscle obtained by an assistant from the patient's thigh No evidence of invasion of the dura was seen The osteoma was chiseled and rongeured from the removed bone until a normal contour of outer and inner tables had been achieved The bone flap with its central part of tumor was boiled for twenty minutes and then replaced It was anchored with silk sutures (4) passed through drill holes in the bone edges The scalp was then closed without drainage

Convalescence was uneventful except for the collection of fluid beneath the scalp necessitating several aspirations The patient left the hospital on the sixteenth postoperative day An x ray four months later (Fig 43) showed extensive decalcification of the graft The patient was seen eight and one half years later He had no complaints The region of the graft was slightly depressed but firm and solid His only concern was his recent rejection for military service

Comment—This was an entirely satisfactory result and illustrates the usefulness of this technic Even with the present availability of tantalum this seems the best method of immediate repair of a skull defect in such a situation.

CASE VI—A C a 22 year old man had been operated on four months before because of a compound skull fracture of the right posterior parietal region A single large loose fragment of bone was removed and preserved The patient returned for repair of the skull defect about which he had expressed great concern Figure 44 shows the extent of the defect The scalp wound was reopened and the edges of the bony defect were exposed The previously removed piece of bone which had been preserved in alcohol was boiled for twenty minutes and then replaced It was anchored by silk sutures (3) passed through drill holes in the bone edges The scalp was closed without drainage

Convalescence was again uneventful The wound healed except for one point which drained persistently Figure 45 shows the roentgenographic appearance of the graft four and sixteen months respectively after its placement The drainage from the original sinus persisted and other sinuses developed It was finally necessary to remove the graft which was done eighteen months after it had been inserted The wound then promptly healed and has remained so The patient has since been offered a repair with a tantalum plate but decided against any further surgery

Comment—This was an ill advised procedure and was unsuccessful A boiled bone graft should never be used at a secondary procedure Its only place is in a primary procedure where it is desired to kill

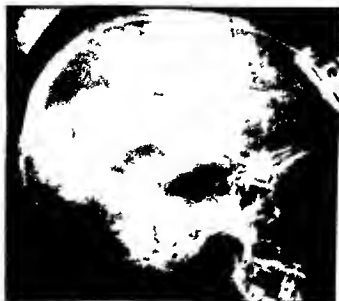


Fig 44 (Case V I) --Post traumatic parietal skull defect Lateral view



Fig 45 (Case VI) --Autogenous boiled bone graft in a post traumatic defect sixteen months after placement Chronic wound infection present Lateral view

tumor cells that invade the bone and then replace the bone. Under such circumstances it has been entirely satisfactory in a number of the writer's cases.

Alloplastic Grafts—As stated above, periosteal outer table grafts are not suitable for large defects or those involving the superior orbital ridge. Autogenous rib grafts have the disadvantages already referred to of increasing the extent of the operative procedure and of not being entirely satisfactory from a cosmetic standpoint. Consequently when reports began to appear regarding the noncytotoxicity of vitallium we were favorably impressed and our first experience with alloplastic grafts was with this alloy.

CASE VII—G M, a 38 year old male Negro, had been operated on ten months before for osteomyelitis of the frontal bone. There was a large midfrontal defect of the skull that measured about 10 by 15 cm (Fig 46). The patient desired repair of this for cosmetic reasons. Through the cooperation of the department of



Fig 46 (Case VII)—Postoperative frontal skull defect. Lateral view.

oral surgery a plaster mold of the patient's defect was obtained. This was furnished the Austenal laboratories who constructed a vitallium plate to fit the defect furnished with flanges (4) with holes for countersunk vitallium screws.

The former scalp incision was reopened and the edges of the bony defect exposed. The plate fitted the defect satisfactorily except posteriorly where it was not curved enough to conform accurately to the curvature of the skull. It was bent somewhat in its posterior part in order to attain this curvature. It was attached to the skull by the four screws through the flanges. The scalp was then carefully closed. Convalescence was again satisfactory with the wound healing by primary intention. Figure 47 shows a postoperative roentgenogram.

Comment—This was an entirely satisfactory repair. Although exact conformation of the plate to the skull was not obtained there was no external evidence of this lack of conformation. This was our first ex-

perience with vitallium but it was so satisfactory that we continued to use it for the repair of large skull defects until April, 1944, when tantalum was first available to us. With increasing experience in construction of the molds of the defects we obtained plates of better contour with more accurate conformation of the plates to the skull. No difficulty was noted with the plates after they had been inserted and wound healing was always prompt. However, the disadvantages of working with an alloy that had to be cast in advance of the operation and the limitation of plates that could be molded little if at all at operation are obvious.

Tantalum, because of the readiness with which it can be trimmed and molded, can easily be prepared at the operating table. Curved

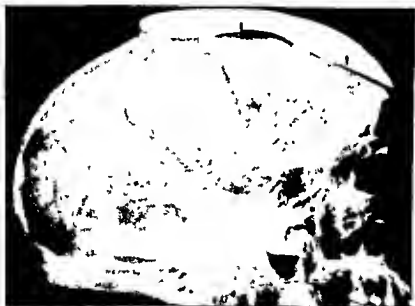


Fig 47 (Case VII).—Repair of postoperative frontal skull defect with a vitallium plate. Lateral view.

wooden forms and a ball-peen type of hammer are useful. A rudimentary knowledge of working metal by hand and a little practice are all that is necessary to achieve satisfactory results. In many skull defects that are the result of trauma, additional removal of bone with consequent enlargement of the defect may be necessary at operation. Preformed plates are not satisfactory in these cases. However, a number of surgeons (Hamberger, Whitcomb and Woodhall, Woolf and Walker, Mayfield and Levitch, Robertson and Woodhall and Spurling) have advised the preparation of preformed plates and have devised methods for this.

Various methods of anchoring the plates are available. A ledge may

be cut in the outer table of the bony edge of the defect so that the plate may be countersunk. A small chisel as a dental chisel is most convenient for this. The plate is of course trimmed to fit onto this ledge of bone rather than into the defect itself. Tantalum wire sutures may be passed through drill holes in the plate thus wired in place. However, these wire sutures may irritate the overlying scalp and even cause pressure necrosis. A better method of anchoring the plate is to fix it with small triangular wedges of tantalum driven into the diploe after the fashion of a window glazier. These are tapped into place using a small punch and a light mallet. Until very recently tantalum screws have not been available but now that they are the use of these screws should be satisfactory.

Recently to save time I have not prepared a ledge entirely around the bony defect but have chiseled off the outer table at several points to provide a ledge about 1 cm square. The plate is then cut to fit the defect but with flanges corresponding to the ledges that have been cut. One or two tantalum wedges are driven into the diploe over each flange thus fixing the plate. Screws can also be readily used to fasten the plate through drill holes in each flange.

The plate should be perforated unless it is placed over the denuded cerebral cortex. The perforations permit the growth of soft tissues through them with consequent additional fixation of the plate and obliteration of the dead space between scalp and plate. If the plate is not perforated fluid may accumulate persistently between it and the scalp. Bakody has reported one such case in which the persistent accumulation of fluid in spite of repeated aspirations necessitated the removal of the plate three months after its placement. It was removed, perforated and replaced in one stage. The wound promptly healed and there was no further accumulation of fluid.

CASE VIII—W. M., a 15 year old boy had a large right subtemporal depression six months before because of an epidural hemorrhage. He returned for repair of his defect about which he and his family were greatly concerned. His parents had not permitted him to return to school because of the presence of the defect (Fig. 48).

The former horseshoe shaped musculocutaneous flap in the right temporal region was reflected. The edge of the bony defect was exposed and then with a small chisel and mallet the outer table was cut back for about 3 mm to provide a ledge. A tantalum plate 0.02 inch in thickness which had been previously perforated was hammered to a suitable contour and trimmed so as to fit the ledge prepared for it. It was fixed by a number (9) of small wedges of tantalum driven into the diploe and hammered down onto the edge of the plate. The scalp was then closed without drainage. Convalescence was uneventful. Figure 49 is a post-operative roentgenogram. The patient was seen and presented to a large clinic six months later. He was working steadily and attending school at night.

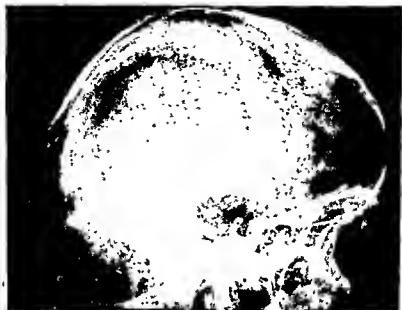


Fig 48 (Case VIII).—Postoperative parietotemporal skull defect. Lateral view.

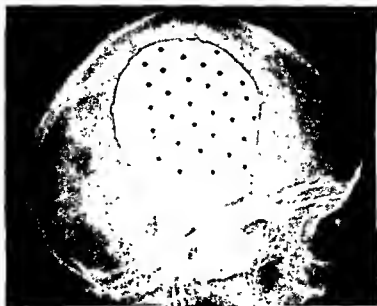


Fig 49 (Case VIII).—Repair of parietotemporal defect with tantalum plate. Fixation with tantalum wedges. Lateral view.

Comment.—This was an entirely satisfactory result. There was no postoperative accumulation of fluid, the wound healed promptly, and the cosmetic result was excellent.

CASE IV—T S, a 45 year old white man, was operated on seven months before for extensive osteomyelitis of the frontal bone with production of a skull defect that measured 15 cm in both anteroposterior and transverse diameters. He returned for repair of this tremendous disfiguring defect. The previous coronal incision was reopened and the scalp reflected. The edges of the defect were exposed and a ledge prepared by chiseling off 2 to 3 mm of outer table. A standard size 6 by 6 inch tantalum plate 0.02 inch thick was hammered to the proper contour, its corners trimmed off so as to allow it to fit on the prepared ledge, and then a number (10) of tantalum wedges were hammered into the diploe and bent over the edge of the plate. The plate was not perforated. The scalp was closed without drainage. This was a long and tedious procedure and because of operative shock the patient was given 1000 cc of blood during and after the operation. The wound healed satisfactorily but accumulation of fluid between plate and skull necessitated a number of aspirations. The patient left the hospital one month later. (See Fig 49a.)



Fig 49a (Case IV) —Repair of large frontoparietal skull defect with tantalum plate. Fixation with tantalum wedges. Anteroposterior and lateral views.

Comment—This is the largest defect the writer has ever repaired. The use of flanges on the plate with corresponding small ledges on the skull would have reduced the operating time considerably. Although the defect was large, involving almost all of the frontal and part of the parietal bones, a satisfactory cosmetic result was obtained without the use of a preformed plate. Omission of the perforations was a serious mistake and led to the persistent accumulation of fluid between scalp and plate. Fortunately, after a number of aspirations the fluid ceased to accumulate.

CASE V—M H, a 20 year old Negro male, had been operated on three months before for a compound skull fracture of the frontal bone that involved both frontal sinuses. The patient returned for repair of the defect in the midfrontal region. The previous scalp laceration was reopened and the edges of the bone defect exposed. A perforated tantalum plate was hammered to the proper contour and then cut to fit the defect with three small (8 by 10 mm) flanges. Small ledges corresponding to these flanges were cut in the bone edge by removing the outer table

and anchored by driving small tantalum wedges into the diploe and bending them over the flanges. The scalp was closed in the usual way. Convalescence was again uneventful and the cosmetic result satisfactory (Fig 50).

Comment.—This was the first plate in which only seats for flanges were cut in the outer table. This significantly shortens the operating time especially with large plates where cutting the ledge for the plate is a long and tedious process. Now that tantalum screws are available it is a simple matter to drill a hole in each flange and then screw it into the diploe and inner table. In the past we have usually removed the outer table entirely when cutting a ledge for the plate or seats for



Fig 50 (Case X) —Repair of frontal defect with small tantalum plate. Fixation with flanges and tantalum wedges. Anteroposterior view.

the flanges. Unless the diploe were exposed, tapping the wedges into the bone was very difficult if not impossible. When screws are used it is unnecessary to remove more than a thickness of outer table corresponding to the thickness of the plate (0.015 to 0.02 inches). Indeed countersinking is probably not necessary at all when using screws.

REPAIR OF SMALL DEFECTS

Tantalum has recently been used for repair of small skull defects such as burr holes. Boldrey has currently used stainless steel wire-mesh for this purpose. In the usual transfrontal craniotomy the anterior

burr hole is well below the hairline just above the frontal sinus and just to one side of the midline. Unless this is repaired an unsightly depression results. Until recently we had always followed Adson's suggestion and had filled this burr hole with some bone dust, saved when the burr holes for the bone flap were made. This was wrapped in a small piece of Cargyle membrane and plugged into the burr hole after the bone flap was replaced. A flap of periosteum was then sutured over it. This was not always satisfactory. On a few occasions the bone dust and Cargyle membrane seemed to produce irritation and a draining sinus developed in the scalp incision and persisted for a time. The



Fig 51.—Repair of frontal burr hole of an osteoplastic craniotomy with a small button of tantalum Anteroposterior view.

end result from a cosmetic standpoint was not satisfactory in these cases. In some other cases absorption of the bone dust gradually left a visible depression.

Recently we have used a small button of tantalum cut to fit the burr hole and with one or two small flanges. Small seats for the flanges are cut in the outer table. The tiny plate is anchored in the usual way with tantalum wedges. Figure 51 is a roentgenogram taken after operation in such a case. No attempt has been made to repair the other burr holes which are within the hair line and of no cosmetic importance.

CONCLUSIONS

The repair of skull defects is indicated in a great many cases. It is, however, an elective procedure and in some cases is contraindicated.

It should not be undertaken in compound or contaminated wounds but only some time after such wounds are completely healed and when there is no evidence of intracranial infection.

The available choice of material is a wide one but practically can be narrowed down to autogenous grafts or to the newer noncytotoxic, alloplastic materials. Tantalum is quite satisfactory for the repair of skull defects of various sizes. It is malleable and can be formed to fit most defects at the operating table. It is strong and can thus be used in very thin plates. Although no long time observations are available it appears to be noncytotoxic and entirely inert in the tissues. Consequently there will be no difficulty with wound healing, provided of course that surgical principles are not violated by introducing it in the presence of gross infection or chronic tissue inflammation. It is radiopaque so that, as Woolf and Walker point out, large plates will interfere with subsequent roentgenographic examinations. Because of this these authors recommend the use of plastics, specifically methyl methacrylate. However, this like vitallium has to be preformed and cannot be molded or otherwise significantly altered at the operating table. Tantalum possesses great advantages in this respect. Even if the surgeon prefers to preform the tantalum plate it can still be altered at the operating table if necessary. For this reason tantalum will probably be preferred to methyl methacrylate, at least until a malleable and ductile plastic with sufficient rigidity is discovered.

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THE TECHNIC OF LUMBAR SYMPATHECTOMY

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FROM the early gropings of the middle twenties there developed a procedure for which indications have become clear and whose technique could be standardized. Lumbar sympathectomy arose from nebulous indications and among much controversy regarding its lasting effect on circulation. Even the anatomic approach to the retroperitoneal sympathetic ganglionated chain has varied from a transperitoneal to a retroperitoneal exposure, finally resulting in a simple anterolateral muscle splitting extraperitoneal approach which will be presently described. The credit for the development of this approach rests with surgeons on the West Coast, notably Livingston Pearl and Flothow.

PRELIMINARY CONSIDERATIONS

Indications—Since the lumbar sympathetic chain is accessible to infiltration with procaine a paravertebral sympathetic block must precede any surgical removal of the ganglionated trunk (Fig 52). During the temporary block produced by the local anesthetic, one can test for the rise in skin temperature of digits for the improvement in intermittent claudication and for the changes in venous filling time (Fig 53). It must be stated however, that this temporary effect is not the equivalent of the lasting effect of sympathectomy. In some respects it does much more, in others much less for the state of blood flow in the extremity. All one wishes to demonstrate with the procaine block is the capacity of the vascular bed to dilate when a central or reflex vasoconstriction is abolished, the late, permanent effects of sympathectomy are briefly the freedom of the vascular bed from constrictor impulses which come to it from central stimuli such as emotion reflexly after exposure to cold environment and from being in the sitting or standing position. Most often ignored is the postural vasoconstriction which operates in all human beings in order that blood pressure is maintained in the erect position. This is abolished in the sympathectomized extremity (Fig 54).

Generally speaking, sympathectomy puts the vascular bed at rest. It stabilizes the blood flow in the extremity, which shows surprising fluctuations in the nonsympathectomized limb.

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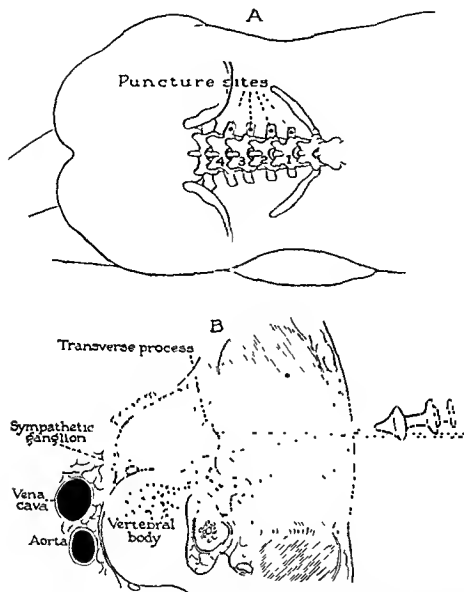


Fig. 52.—Lumbar sympathetic block. The patient is on his side, with the side of injection uppermost. Four wheals are made 2 to 3 fingerbreadths lateral to the upper border of the first four lumbar spinous processes. The wheals are made with a fine hypodermic needle, and a longer needle may be used to anesthetize the sensitive lumbodorsal fascia. Next, a 6-inch long 22 gauge needle is used and inserted perpendicular to the plane of the back. It should contact the transverse process at a varying depth. It is then withdrawn and redirected above or below the transverse process to meet the body of the vertebra at an angle of 25 to 30 degrees. Since this first point of contact is not anterior enough to infiltrate the ganglionated trunk, a second withdrawal and a second contact is made with the body of the vertebra; this time the needle is more closely parallel to the lateral surface of the body. Ten cubic centimeters of 1 per cent procaine solution is injected to each lumbar segment. In experienced hands, one deposit of 30 cubic centimeters of the same solution may suffice to get a satisfactory block of the lumbar sympathetics as evidenced by lack of sweating and increase in skin temperature. (From *Military Surgical Manuals*, National Research Council, Vol. 5, W. B. Saunders Company, Philadelphia and London, 1943.)

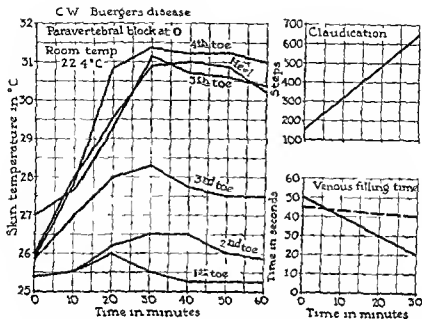


Fig 51—The results of paravertebral sympathetic block in a patient suffering from Buerger's disease. Graph on left shows the rise in skin temperature of the 4th and 5th toes to the normal vasodilatation level (31° C). The heel warms up equally well. The 3d toe warmed up from 26° to 27.5° C. The 1st and 2d toes did not warm up at all. Such a patient needs an amputation of his 1st and 2d toes, the 3d toe will remain cold after sympathectomy, but may improve with time. This same patient could walk 650 steps after sympathetic block without getting pain in the calf, against 150 steps before the block. This indicates that angiospasm is a factor in his claudication. The venous filling time (venous filling on the dorsum of the foot after 60 mm of mercury pressure was inflated into a blood pressure cuff on the thigh) dropped from 50 to 20 seconds on the injected side, the change on the opposite side from 45 to 40 seconds is within the limits of error. Lumbar sympathectomy with amputation of the first two toes resulted in an excellent anatomic and functional recovery. (From de Takats, G. The Value of Sympathectomy in the Treatment of Buerger's Disease. *Surg, Gynec & Obst*, 79:359, 1944. By permission of Surgery, Gynecology and Obstetrics.)



Fig 54—Blood pressures registered with a double-cuff oscillometer at the right and left calves of Mrs. L. F., a 42 year old hypertensive patient after right-

A brief tabulation of the indications as observed in our vascular surgical service is shown in the accompanying table. For a detailed discussion of the indications for sympathectomy in peripheral vascular disease, previous publications from this clinic may be consulted.

INDICATIONS FOR LUMBAR SYMPATHECTOMY

<i>Diagnosis</i>	<i>Indications</i>
Congenital vascular anomaly	In spontaneous arterial thromboses—preliminary to arterial ligatures
Aneurysms	Preliminary to excision of arterial or arteriovenous sacs
Exposure to cold frostbite immersion limb trench foot	Late stages exhibiting marked vasospasm and hyperhidrosis Poorly demarcating gangrenous patches
Causalgic states	Sympathetic block provides relief but pain relief is only temporary
Posttraumatic vasospasm	If repeated paravertebral blocks fail—be wary of psychoneurotosis
Raynaud's phenomena	Lack of sclerodactylia rarely in lower extremities
Acroraynosis	Conservative treatment fails Test for end agglutination
Livedo reticularis	For pain or ulceration cosmetic result doubtful
Bierger's disease	Absence of acute inflammation or disturbed clotting mechanism Good response to sympathetic block
Arterial embolism	Postembolic ischemia or threatening necrosis Ischemic neuritis of short duration
Arteriosclerosis	Athetomatous occlusion of major pathways No advanced lesion in visceral organs Good response to sympathetic block

Anesthesia—While in former years intratracheal ether anesthesia was occasionally employed I have lately refused to operate under any form of anesthesia except spinal. In any group of patients there will be a small minority who wish to be put to sleep and if there was no definite contraindication to the use of a general anesthetic we usually acceded to the wishes of the patient. The muscle splitting incision and

sidelumbodorsal sympathectomy. Lower curves were obtained in the horizontal upper curves in the erect position. At the left calf there is a striking rise in peripheral resistance when the patient stands; the blood pressure rose from 180/80 to 250+/140. This is the nonoperated side. At the right calf (sympathectomized) the height of the oscillations has greatly diminished; the pressures are registered as being 185/85. In the erect position, the marked shift to left seen on the control side does not exist. The stroke volumes are small; the pressure can be read with some difficulty between 190 and (?) diastolic. Peripheral resistance in the erect position is so small that the diastolic decline of the pulse wave is indistinct. The curves indicate that the marked postural vasoconstriction has been significantly dampened by sympathectomy.

the stripping of the peritoneum however, require such absolute muscular relaxation that general anesthesia cannot always be depended upon. Furthermore patients requiring lumbar sympathectomy usually suffer from vascular disease which may have affected visceral organs notably the heart brain or kidney. The strain on these organs is decidedly less under spinal anesthesia provided the maintenance of blood pressure is jealously guarded.

One should require from a spinal anesthetic for lumbar sympathectomy that it reach to approximately the sixth dorsal segment that it provide a complete muscular relaxation and a sensory loss for about one hour. While most lumbar sympathectomies may be unhurriedly performed between thirty and forty five minutes a certain latitude is preferable for unforeseen difficulties.

The anesthetic of choice in our experience has been from 12 to 16 mg. of pontocaine in 10 per cent glucose solution. The blood pressure is maintained with ephedrine neosynephrin or paredrine. The choice of this vasoconstrictor is left to the discretion of the physician anesthesiologist who has taken a considerable burden off the surgeon's shoulders by taking charge of this phase of the problem. He may also employ oxygen inhalations for nausea pallor or dyspnea. For the surgeon who has to work with nurse anesthetists it becomes necessary to have a report on the blood pressure as soon as it drops to 90 mm. of mercury (systolic) and have neosynephrin administered in doses of 0.2 to 0.3 cc. into the muscle. This may have to be repeated once or twice during the operation. A prophylactic dose given simultaneously with the spinal anesthetic is highly recommended.

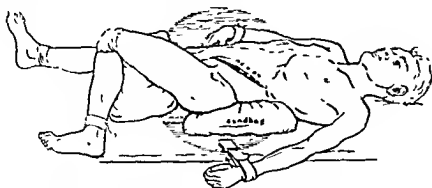
If hypertensive patients are being operated on the optimal level to be maintained is the preoperative pressure at rest in bed. A drop of blood pressure from 180 to 100 mm. of mercury is of course more objectionable than a drop from 110 to 90 mm. of mercury.

In most institutions the premedication is also in the hands of the department of anesthesia. A barbiturate such as nembutal or seconal in doses of $1\frac{1}{2}$ grains (0.10 gm.) followed by morphine scopolamine in a ratio of 1:25 one hour before the operation is quite satisfactory. In elderly patients with cerebrovascular sclerosis a barbiturate may be preferable to the narcotics which often confuse them.

The greatest objection to spinal anesthesia is a postoperative head ache which occurs in a small number of cases in spite of the precaution to keep the patient's head down for twenty four hours and have the bed in a Trendelenburg position. Aminopyrine and benzedrine sulfate have been of some help.

Position of the Patient—The patient is placed on his back with a large sandbag under the lumbar region the hip and knee are flexed and swung over to the opposite side. A loose calico knot may be tied around the ankle and secured to the opposite side of the table to prevent the lower extremity from slipping. The purpose of this position

is to relax the anterior abdominal muscles and chiefly to relax the psoas muscle. If this muscle is in the way and cannot be readily retracted, the exposure of the ganglionated trunk is greatly handicapped (Fig. 55).



1. Position of Patient.

Pelvis rotated 30°
Hip and knee flexed



2

External oblique
split and retracted
Incision in
internal oblique

Position
of surgeon

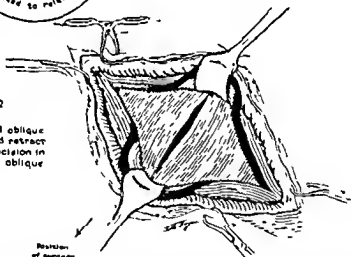


Fig. 55.—1. The patient is on his back with a sandbag under the lumbar region rotating his pelvis. Hip and knee are flexed to relax the psoas muscle which facilitates retraction. The incision extends from the midaxillary line at the costal margin along the course of the external oblique muscle and ends at the lateral border of the rectus muscle. 2. After skin towels are placed, the external oblique muscle is cut in its lower tendinous portion followed by a blunt separation of the muscle fibers. The muscle is retracted with blunt retractors or automatic spring retractors. An incision is now made into the internal oblique, parallel with its fibers, approximately 3 inches above the umbilicus, as close to the costal margin as possible.

THE OPERATION

The site of incision is marked with a 2 per cent aqueous solution of brilliant green. It starts in the midaxillary line where this crosses

the costal margin and runs parallel with the course of the external oblique muscle to the palpable edge of the rectus. This is approximately at McBurney's point. Obviously much depends on the anatomic build of the patient, on his nutritional state, and on his muscular development. Some men may pride themselves on a short incision but generally speaking the shorter the external incision the greater the internal struggle.

The skin and subcutaneous fat are divided with a clean sweep to the aponeurosis of the external oblique muscle. Nothing is gained by undermining the skin and the muscle should be divided in the direction of the skin incision. It is best to cut first the tendinous part of the muscle and then bluntly separate the belly of the muscle. The external oblique muscle should be separated for the full length of the incision since it otherwise interferes with the separation of the deeper layers. A pair of Farr retractors is convenient to keep the two flaps of the muscle well separated.

This retraction exposes the fibers of the internal oblique muscle, which is practically at right angles to the previous layer. It is best to nick the fine but tenuous fascial covering with a scalpel and then bluntly separate the muscle with a Kocher dissector. The muscle is then gently separated with the two index fingers. Should a vessel tear during the separation, it is promptly ligated with No. 60 cotton. Ordinarily, however, the separation of the external and internal oblique muscles can be done in avascular areas. The internal oblique muscle has to be separated as close to the costal margin as possible, about the level of the second lumbar vertebra approximately 3 inches above the umbilicus, since the higher the approach to the chain, the more readily can it be removed. The two muscle flaps are retracted with short, stocky, blunt retractors so as to expose the transversalis muscle and the underlying fascia (Fig. 56). For the first time nerve trunks with accompanying vessels become visible. Two nerves are quite constant and represent the anterior rami of the lower thoracic nerves, the subcostal from the twelfth intercostal nerve and the iliohypogastric from the first lumbar segment are most constant. These nerves run between the internal oblique and the transversalis muscles. They give off motor twigs to the anterior abdominal muscles and lateral cutaneous branches which are sensory. The splitting of the transversalis muscle must take place between these nerves and one must avoid putting them on too much traction since paralysis of the abdominal muscles may result.

When the transversalis muscle and fascia have been bluntly separated, the preperitoneal fat comes into view. The two index fingers make a wide sweep parallel to the longitudinal axis of the body, so that a large arc of the peritoneal fat with the underlying peritoneum becomes exposed. It is important to stay close to the peritoneum and not get lost in the paraperitoneal fat which may be heavy.

and often vascular, also the dissection should proceed laterally, since the peritoneum may tear close to the lateral border of the rectus sheath. With the help of the finger or a stick-sponge this lateral fat

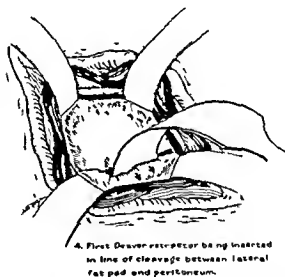
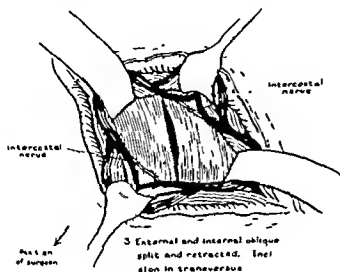


Fig 56—The internal oblique muscle is retracted bringing the transversalis muscle into view, together with the subcostal and iliohypogastric nerves, which should be protected. The transversalis muscle and fascia are split along the direction of their fibers which exposes the preperitoneal fat and a lateral fat pad. By blunt dissection with the two index fingers a line of cleavage is established between the peritoneal reflection and the lateral fat pad. The peritoneal sac may now readily be pulled medially over the psoas until the bodies of the vertebrae with the aorta or vena cava are exposed.

pad is pushed away so that the blunt stripping of the peritoneum stays close to its glistening white reflection. Such a dissection will lead straight down to the psoas muscle, whose sheath must be entered and dissected cephalad (upwards).

At this point four Deaver retractors must be inserted (Fig 57), one retractor holds the peritoneal sac medially. The second retractor is placed against the renal fascia and the costal arch, traction on this retractor is directed medially and upwards to expose the upper angle of the surgical field. The third retractor is placed in the lower angle of the field and exerts traction caudad (downwards). The field is

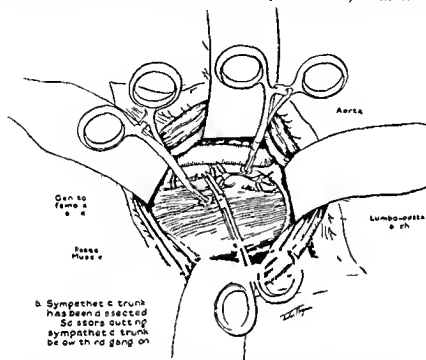


Fig 57—Four Deaver retractors are used to expose the field. The medial retractor holds the peritoneum, the ureter and its surrounding vascular plexus. Cephalad the retractor lifts the perirenal fascia and exposes the fascial margin of the diaphragm. Caudad the retractor holds the iliac bifurcation and the contents below the sacral bend. The lateral retractor holds the abdominal wall with the paraperitoneal fat. The genitofemoral nerve is protected from all pressure since retractor neuralgia is not uncommon. The ganglionated trunk is sectioned well below L₃ and above L₂; the course of the ramus is caudad at the third cephalad at the second ganglion. The aorta (or vena cava on the right) and the psoas muscle are best retracted with sponge sticks.

illuminated by a head lamp with a mirror reflector which lights up the area far better than lighted retractors do.

On the left, the medial retractor covers the ureter and may also retract the aorta; on the right the vena cava should not be included in the retraction, but allowed to be fully visible in the field. A vigorous instrumental retraction of the vena cava may result in tearing off some of the lumbar tributaries and produce cumbersome if not dangerous bleeding.

Neither the vena cava nor the psoas muscle should be retracted with instruments, only small stick sponges should be used. The vena cava has to be pushed well to the midline with a sponge resting on the vertebral body since the sympathetic chain lies well *under* the vein at the level of the sacral promontory. On the left the chain lies lateral to the aorta and is thus more readily exposed.

For lateral retraction of the psoas muscle, again a small sponge on a long handle is the gentlest. The muscle itself is not so vulnerable as the genitofemoral nerve which runs almost parallel with its fibers. A contusion or stretch of this nerve is not uncommon if heavy retractors are used and may lead to long-lasting paresthesias in the femoral triangle and in the skin of the scrotum. Occasionally the lateral cutaneous nerve of the thigh which appears at the lateral border of the psoas may be traumatized and can suffer because of unskilled traction.

The area then in which we look for the ganglionated trunk is widely exposed. Medially this area is bounded by the aorta or vena cava, these vessels may often be covered by excessive fat or lymph glands, but the chain is firmly bound to the vertebral bodies with a strong fascial duplication and should be looked for immediately over the bone. It is readily identified by rolling it over one's index finger in a transverse direction. Laterally the psoas muscle presents itself. The muscle should be relaxed by the patient's position on the table and not bulge into the field. Caudad, the sacral promontory with the aortic bifurcation is being felt and seen, whereas cephalad the lumbocostal arch limits the extent of dissection.

The segment of sympathetic trunk to be excised extends then from the level of the aortic bifurcation to the diaphragm. The fourth lumbar sympathetic ganglion is at the bottom of the field. It is enough to section the trunk just above it and its removal is not necessary. The chain may now extend upward in the form of a sturdy trunk or of two or more fine strands until the third and second ganglia are seen. The second ganglion can be identified by the direction of the communicating rami, which come to it from above, whereas the third ganglion receives its rami from below. There is a great deal of variation in the size and number of ganglia, but the object of the operation is to remove the ganglionated trunk from the sacral promontory to the lumbocostal arch. This segment usually includes the third and second ganglia. The first ganglion is hidden within the arches of the diaphragm and can hardly be reached from this exposure.

The dissection of the chain begins at its lower end, where the upper end of the fourth ganglion is evident. The ganglion is a grayish pink oval firm structure. It is tough, unlike a lymphatic chain. It has to be lifted out of its tense sheath with a vigorous sweep of a Crile dissector. It is then hooked up with the other end of this instrument, so that its rami are visibly on a stretch. The distal end is clipped with a Cushing clip and the proximal one lifted with a long curved forceps.

The dissection is now carried cephalad, bluntly, staying close to the trunk and its ganglia. Lumbar veins, entering the vena cava, may cross the chain in front or behind it. If they are anterior to it they may have to be cut between two Cushing clips although often the chain can be pulled through under them without any injury. Should bleeding occur from lumbar veins, or branches of lumbar arteries, the Cushing clip on a 10 inch carrier is a most satisfactory way to control hemorrhage. Small oozing may be controlled by hot laps and pressure exerted for a few minutes. Among several hundred lumbar sympathectomies, our service has not encountered any intractable hemorrhage.

When the chain is cut above the second lumbar ganglion complete hemostasis is secured the sponge count is requested, and then reconstruction of the wound is begun. The peritoneum readily falls back into place and the first sutures are placed in the transversalis muscle and fascia. From three to four interrupted No. 20 cotton sutures are placed between the carefully protected anterior rami of the intercostal nerves. Next the internal oblique muscle is approximated with a few interrupted cotton sutures of the same strength. Finally the external oblique muscle and its aponeurotic part are closed with No. 2 cotton sutures. No sutures are placed into the subcutaneous fat, but all bleeding points are carefully ligated with No. 60 cotton suture rolled out from a ligature-ball which has been in use on our service for twenty years. The skin is united with interrupted black cotton sutures. Dry gauze is applied to the suture line held in place with: 'masticol glue'. Three strips of elastic adhesive tape are used to keep mild pressure on the wound.

POSTOPERATIVE CARE

The patient is not permitted anything by mouth until the night of the operation, after which time he may have liquids. Food permitted as desired on the day of the operation often leads to distention, nausea and vomiting. He is given 2000 cc. of 5 per cent glucose solution, one liter in normal salt solution and the second liter in distilled water. For pain relief he receives $\frac{1}{4}$ gram (0.001 gm.) of morphine, for intestinal and bladder atony, 1 cc. of a 1:2000 ampule of prostigmine is administered. Both of these drugs are given every six hours for the first two days. Catheterization seldom becomes necessary, but should be done every eight hours to prevent overdistention of the bladder.

The patient is kept in bed in a Trendelenburg position for the first twenty-four hours. This is because of the postspinal headache which has been infrequently seen since the use of fine spinal needles but which still occurs in spite of all known precautions. On the day following operation the patient is encouraged to get out of bed and be up as much as desired. Only in patients who have ulcerated or gangrenous toes or who have had minor amputations combined with

* Gum mastic 40 gm. benzol 60 gm. castor oil 20 drops benzol q.s. ad 100 cc.

sympathectomy is it necessary to keep the patient from ambulation, even so they may get out into a wheel chair, without any weight bearing on the affected limb.

A small enema is given the third postoperative day. If this is successful the patient is placed on a general diet. Increased colonic peristalsis irritable, spastic phenomena are seen very infrequently, much more often after splanchnic nerve section combined with lumbar sympathectomy. From our experience with lumbar sympathectomies for megacolon we know that the elimination of sympathetic inhibition leads to increased colonic contractions and a more rapid passage of fecal material. Nevertheless, clinically this parasympathetic dominance on the bowel is unnoticed by most patients. Occasionally if the diet is too rough in the first few days phenobarbital and belladonna may become necessary. I have never seen diarrhea or a syndrome of chronic 'spastic' colon develop after bilateral lumbar sympathectomy.

Stitches are removed on the eighth day, the patient may leave the same day or have the other side operated on.

EFFECTS OF LUMBAR SYMPATHECTOMY

With the removal of the ganglionated trunk with its second and third lumbar ganglia the preganglionic sympathetic outflow to the lower extremity is interrupted. The vessels of the sympathectomized region still respond with constriction to the direct effect of cold but the chilled extremity warms up much faster than the nonoperated one. The vessels will not constrict or dilate on central or reflex stimuli, that is to say, neither emotion nor a cold drink, a cold draft on the neck, a painful pinch nor a deep breath will effect a vasoconstriction. These are just a few of the stimuli which cut down blood flow day after day. Nor is man the erect animal capable of constricting the vascular bed when he stands. This regulatory mechanism which operates for the purpose of maintaining blood pressure in the erect position is eliminated by lumbar sympathectomy and again insures a more even blood flow.

This does not mean, however, that patients who have undergone bilateral lumbar sympathectomy exhibit a fall in blood pressure when arising. This is true of patients when splanchnic nerve section is added to bilateral lumbar sympathectomy in cases of hypertension. But even here this effect is transitory and is clinically not noticeable after the first month or six weeks.

The patient then who has undergone a lumbar sympathectomy possesses a blood flow of an individual whose normal vasomotor activity is not activated by temperatures lower than 85° F. His leg is in Florida while he works at a factory job in Chicago. Furthermore his postural vasoconstriction is abolished, he is up and around but his sympathectomized leg has the blood flow of a man in bed in the horizontal position.

The sympathectomized area does not sweat. Without the necessity of running special tests for sweating, palpation with the hand easily reveals the extent of denervation, for the average case, the sympathetic denervation of the second and third lumbar ganglia is perfectly satisfactory, the anterior surface of the thigh is moist and there may be a moist strip on the lower leg corresponding to the saphenous nerve the branch of the femoral which receives sympathetic fibers from the first lumbar ganglion. The posterior surface of the thigh is dry (Fig 58)

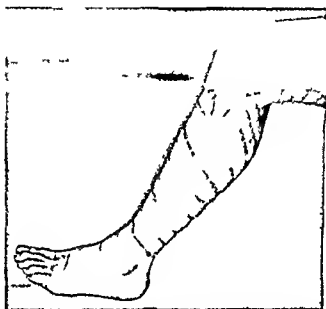


Fig 58—The shaded area represents the extent of sympathetic denervation after the excision of the second and third lumbar sympathetic ganglia. The increased skin resistance in this area was measured by Curt Richter's dermatometer. (By courtesy of Captain Howard H. Hamlin, Mayo General Hospital, Galesburg, Illinois.)

There has been much discussion regarding the male sex function after bilateral lumbar sympathectomy. Most patients coming to operation have heard about loss of libido, orgasm, or of sterility. Many authors state that after the removal of the first lumbar ganglion in the male, the power of ejaculation is lost and specifically that spermatozoa cannot be emptied from the seminal vesicles.

Our experience with this important question has been as follows. Nervous, apprehensive patients who have heard of such a side effect may well develop a psychic impotence. Motile spermatozoa have been seen in condom specimens of a patient who has had bilateral splanchnic nerve section and bilateral excision of the lumbar sympathetic chain from the first to the fourth ganglion. Two other patients with

the identical operation have become fathers * Many patients with bilateral lumbar sympathectomy have reported on normal libido, erection and ejaculation. Most important, however, is the fact that with the approach described, the first lumbar ganglion can be reached with difficulty, is never visible, and is not removed. Thus the discussion is purely academic although legal complications arising from previous statements in the literature may obviously occur. In women, sexual function, pregnancy and birth are undisturbed. According to Shumacker, childbirth is painless in sympathectomized women if we except the perineal pain caused by the pressure of the head.

COMMENT

Lumbar sympathectomy has become a simple, well standardized procedure. There has been no mortality in our hands after several hundred sympathectomies, when infection occurs, drainage may be prolonged because of the difficulty of clearing up the retroperitoneal space. Two such long draining infections have been encountered. The rehabilitating effect of the operation is remarkable, it may have to be combined in the advanced cases of obliterative vascular disease with minor amputations. The improvement in circulation and the stability in blood flow is equivalent if not in many instances superior to many months and years of physical therapy, mechanical vascular exercises, drugs and prolonged bed rest with loss of earning power. The operation promises to become one of the most widely employed procedures in vascular surgery.

SUMMARY

The anterolateral, muscle-splitting, extraperitoneal approach to the lumbar sympathetic chain has been described. The removal of the second and third lumbar sympathetic ganglia is performed under spinal anesthesia, with early ambulation. The two chains can be removed one week apart. If performed with proper indications, the results are very satisfactory.

* This is not such convincing proof as the first one. According to Roman Law *pater semper incertus*.

HEMILAMINECTOMY

A EARL WALSH, M.D.*

EXPLORATION of the spinal canal by a laminectomy has been carried out for over a century. Few evidences of weakening of the back have been seen or reported as the result of this procedure. When exploration for prolapse of the intervertebral disk became commonplace, surgeons, and neurosurgeons in particular, decried the full laminectomy and adapted a partial hemilaminectomy as an adequate approach to the lesion. Some of the older surgeons have referred to the technic as 'key-hole surgery'. With accurate diagnosis of the lesion, however, a partial or even complete hemilaminectomy has certain advantages over a complete laminectomy. Because there is little if any structural weakening of the spinal column, the operation may be considered essentially a soft tissue one, and the period of bed rest and hospitalization may be decreased from a few weeks to one week. This is important since patients kept in bed for longer periods of time are more apt to develop both local and general complications and they require a somewhat longer convalescence before returning to their usual activities. From the patient's standpoint the decreased period of hospitalization and shorter absence from work are important financial considerations.

For these reasons I wish to discuss the use of hemilaminectomy in spinal surgery. It is well known that prolapsed intervertebral disks may be easily removed through the interlaminar space or with the help of a partial laminectomy. But it does not seem to be generally recognized that the use of a hemilaminectomy is equally satisfactory for exploration of the spinal cord, removal of tumors and foreign bodies (such as shell fragments and bullets), chordotomy and drainage of epidural abscesses.

The first patient is a man referred for chordotomy because surgery and roentgen therapy had failed to control a chondrosarcoma of the left ilium.

CASE I INTRACTABLE PAIN IN HIP FOLLOWING REMOVAL OF CHONDROSARCOMA OF ILIUM RELIEF BY CHORDOTOMY

A man aged 44 years was admitted to the University of Chicago Clinics on January 19, 1938, complaining of a painless enlargement of the left hip for approximately two years. A hard lump about the size of a large orange just above

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the left hip was first noticed two years before admission. It gradually but painlessly increased in size. After strenuous exercise or sitting for a long time, a dull ache was felt in the hip.

Functional inquiry revealed no other significant findings. Examination was completely normal except for the local findings. Extending upward and firmly attached to the wing of the left ilium was a bony hard mass about the size of a half grapefruit, which measured approximately 7 cm in width and 12 cm in length. Over it the skin was freely movable. Roentgenograms revealed an irregularly calcified tumor mass arising by a pedicle from the wing of the left ilium (Fig. 59). A diagnosis of chondrosarcoma of the ilium was made and on January 29, 1938, Dr. William E. Adams made a biopsy of the tumor, which was reported as chondroma with ossification. On February 28 the patient was read-



Fig. 59 (Case I)—Roentgenogram of the left side of the pelvis showing the diffuse calcification in the tumor arising from the superior surface of the ilium and sacrum.

mitted to the hospital, and Dr. Adams removed the mass from the ilium. A section taken from this mass was diagnosed as chondrosarcoma of the ilium. Eight months after discharge the mass started to recur and gradually increased in size. The patient returned December 1, 1940, complaining of recurrence of the mass and pain in the distribution of the sciatic nerve. At that time the mass was about 15 cm in diameter and the skin over it was smooth and glistening. There was no limitation of movement of the hip joint. Roentgenograms revealed a large tumor containing a massive deposit of calcium arising from the left sacroiliac joint.

On December 3 and 11, 1940, Dr. Adams removed the tumor and posterior portion of the ilium by a two-stage operation. The tumor was reported as a chondrosarcoma.

The patient was given x-ray therapy, some 3200 roentgen units being administered. A sinus tract developed, which cleared up following curettage.

In April, 1944, the patient began to experience moderately severe pain in the

region of the left hip. He was given further x-ray therapy at that time, 1868 roentgen units being given. He obtained some relief but in December, 1944, the pain recurred requiring codeine two or three times a day. He was referred to the neurosurgical service because of this intractable pain in the left hip. Upon examination the abnormal findings were referable to the left buttock. There was a depressed area in the region of the left posterior gluteal muscles just below the

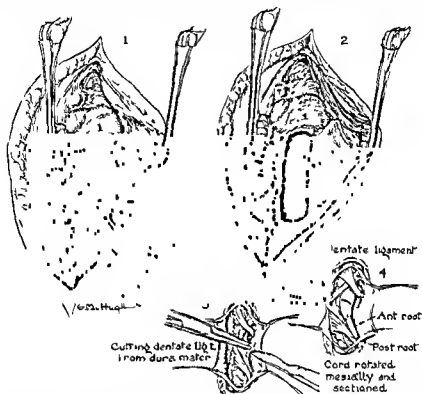


Fig 60 (Case I) —Technic of hemilaminectomy and chordotomy. The muscles are stripped by subperiosteal dissection from the spinous processes of the vertebrae and separated from the laminae by a sponge dissector (1). The laminae are removed opening the posterior foramen (2). The posterior foramen is opened by the removal of the laminae (3). After cutting its attachment to the dura mater the ligament is retracted posteromedially, rotating the spinal cord. An incision 3 mm in depth is made from a point 1 mm below the line of attachment of the dentate ligament anteriorly to the line of exit of the anterior rootlets (4).

iliac crest. The skin over this area was pigmented, and a 12 inch scar passed through it. The movements of flexion and external rotation of the left hip and of dorsiflexion of the left foot were quite weak. The patient limped on the left side in walking. There were no sensory disturbances in the leg. The left knee jerk was absent. An anterolateral chordotomy was advised.

On March 1, 1945, a midline incision was made from the seventh cervical spine to the fourth thoracic spine. The muscles were separated from the right side of

3 - 4 - - ght laminae of the second and third thoracic vertebrae were opened. An incision 3 mm deep, was made and carried out at the line of the anterior roots.

The dura was then closed and all bleeding controlled. The muscles were replaced and sutured along the spinous processes (Fig. 60).

The patient was in good condition throughout the entire procedure. He required catheterization on the first postoperative day but had no further difficulty. He had a marked hypalgesia from the seventh to the twelfth thoracic dermatomes on the left side and analgesia below the twelfth thoracic segment. At times he had fecal incontinence. The left leg remained weak, but not more so than before the operation. He was allowed up on the fourth postoperative day and was discharged on the tenth postoperative day.

He has been followed in the outpatient department. He has had no further pain in the hip but still has weakness of the left leg. The sensory level on the left side has remained at the ninth dorsal dermatome.

Comment—Almost forty years ago Spiller, on the basis of clinicopathological observations, suggested that partial section of the spinal cord would give relief from intractable pain. Since that time the procedure has been used with varying frequency and success. The enthusiasm of the medical profession for chordotomy has been dampened by the complications which may occur after the operation. In the first place, not all patients are completely relieved of pain, due either to an incomplete section of the pain tract or one that was too low. In the second place, even if the pain is relieved, urinary disturbances and debility frequently confine the patient to bed. The reason for both of these sequelae is largely that surgical intervention is "too little and too late." It is difficult for a physician to tell a patient, suffering only slight pain, or his family that all hope of a recovery is past and that an operation on the spinal cord is advisable. It is much easier to suggest that sedatives, analgesics or roentgen ray therapy be tried for a time. After experiencing some relief, when the pain becomes severe again the patient naturally desires more medication or therapy. It is only when the distress has become so agonizing that large doses of opiates dull it only temporarily that the patient, now an addict and cachectic, is willing to consider a neurosurgical procedure. At this time, chordotomy is a formidable operation inviting dire complications which make the procedure much less desirable to the surgeon. On the other hand, if the operation is performed early while the patient is still vigorous, gratifying results can be and are obtained. Under such circumstances, even if some urinary disturbances result the patient usually is able to regain normal function of the bowel and bladder. With the aid of penicillin and streptomycin which may practically abolish urinary infection, chordotomy for intractable pain should have a renaissance which will be gratifying to both patient and physician.

For the relief of intractable unilateral pain, a chordotomy on one side is usually sufficient. Only occasionally must the second spino-

thalamie tract be sectioned to give complete relief. Although weakness of the legs is common after bilateral section of the spinothalamic tracts, little impairment follows unilateral chordotomy. Usually the removal of two laminae gives sufficient exposure for the section of the anterolateral tracts. The chordotomy must be made on the side opposite the pain, for the spinothalamic fibers cross the midline a very short distance after entering the spinal cord. If the origin of the pain is in the lower part of the body the depth of the chordotomy need not be great, for the fibers from the sacral segments of the body lie on the external surface of the cord, if, however, the pain originates from the thoracic region, the section must be carried deeply and forward to the medial margin of the anterior rootlets. The latter portion of the section is important because the higher fibers, entering the spinal cord just a few segments below the site of exposure, lie about the anterior horn and may be missed if the knife is not carried anteriorly far enough.

CASE II NEUROFIBROMA OF SPINAL CORD REMOVAL BY HEMI-LAMINECTOMY

A 52 year old housewife was admitted to the University of Chicago Clinics March 7, 1944, on Dr. Richard B. Richter's service. She complained of numbness and weakness of the legs for approximately one year. Six months before admis-



Fig. 61 (Case II) —Exposure obtained by hemilaminectomy of a neurofibroma of the spinal cord

sion she experienced a feeling of pins and needles associated with numbness and weakness of the left leg. She would stumble if she did not watch where she walked. A few weeks before admission the right leg became weak.

Her past history, family and functional inquiry revealed nothing significant. Physical examination revealed a very obese white woman who did not appear to be acutely ill. Her blood pressure was 140/70. Neurological examination was normal except for the findings in the lower extremities. There was no definite weakness in the legs, but there was a rather indefinite hypesthesia to all forms of

sensation to approximately the lower third of the left thigh. The knee and ankle jerks were hyperactive and the left plantar reflex was extensor.

A lumbar puncture revealed an initial pressure of 170 mm. of spinal fluid. There was no rise on unilateral jugular compression, but on bilateral compression a gradual slow rise to 370 mm. of spinal fluid occurred. Abdominal compression gave a rather rapid rise and fall to 270 mm. of spinal fluid. The fluid was clear and colorless, contained 11 polymorphonuclear leukocytes and 1 lymphocyte. The total protein was 125 mg. per 100 cc. Pantopaque was injected and revealed a block at the tenth dorsal segment.

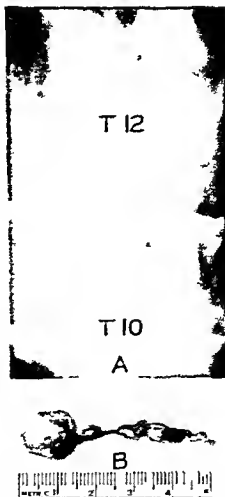


Fig. 67 (Case II) — *A*, Pantopaque myelogram to show the concave tip of the column of contrast media at the site of complete block. *B*, Photograph of the neurofibroma removed through the hemilaminectomy.

The patient was referred to the neurosurgical service on March 14, at which time the findings were as recorded except for a right perianal hypesthesia and bilateral Babinski's signs on plantar stimulation. A review of the myelograms suggested that the tumor lay on the left side of the spinal cord at the tenth dorsal segment. The patient went home for a week to arrange her affairs.

On March 24 she was anesthetized with ether. A curvilinear incision was made from the eighth to the eleventh spines slightly to the left of the midline. The muscles were split subperiosteally from the left side of the spinous processes. The

lamina of the tenth and the lower part of the left lamina of the ninth thoracic vertebra were removed on the left side. There was a small amount of epidural fat. When the dura was palpated it was obvious that there was a nodule at the lower margin of the tenth lamina. The dura was opened. A pearly vascular tumor was present on the left side of the spinal cord. It was easily lifted out but was attached loosely to a nerve root. From this tumor a cord of tissue ran rostrally along a nerve root. This cord was beaded and about three or four smaller nodules were present. The cord was lifted out and dissected from the nerve root to which it was adherent. After complete hemostasis the dura was closed and the muscles were approximated without difficulty. The patient had a smooth convalescence. She was allowed out of bed on the fourth postoperative day and was discharged on the seventh postoperative day (Fig. 61).

The patient has been seen in the outpatient department. She has had no further complaints of numbness and the weakness of the leg has decreased. On examination there was still a slight hypalgesia on the lateral surface of the leg. The tendon reflexes were active and equal; the plantar responses were flexor.

The tumor consisted of an ovoid mass 1.5 cm in diameter from which extended a nodular strand 4 cm in length. The specimen weighed 2.2 grams. On cut surface it had a homogenous granular appearance (Fig. 62).

Microscopic examination of sections stained with hematoxylin and eosin and by Perdrau's technique revealed the tumor to be composed of spindle shaped cells arranged in parallel rows. Areas of necrosis were present. The nuclei were dark staining but no mitoses were seen. The reticulin was practically confined to the blood vessel walls. The tumor was diagnosed as a neurofibroma.

Comment—This case illustrates the fact that if a hemilaminectomy is to be performed the location of the lesion should be accurately known. Not only should the lesion be lateralized but its level in the vertebral canal should be known. It is possible to do an extensive exploration by hemilaminectomy, but technically the procedure is difficult and time consuming. For a prolapsed intervertebral disk, which is usually easily lateralized and localized hemilaminectomy is well adapted. For tumors of the spine, myelography will usually be necessary for an accurate localization. In the above case, the myelogram is typical of a tumor lying on the left side of the spinal cord between the tenth and eleventh thoracic vertebrae (Fig. 62). The concavity at the end of the column of contrast media and the displacement of the spinal cord to the opposite side suggest a spherical extramedullary tumor on the left side.

THE TECHNIC OF HEMI-LAMINECTOMY

Few real advances have been made in the technic of hemilaminectomy in the past few years. A curvilinear incision to either side of the spinous processes is less annoying to the supine patient than a midline one and has the additional advantage in the lumbar region of being able to skirt the site of a previous lumbar puncture which may still be inflamed and perhaps infected. The interspinous ligament is sectioned with the electrosurgical unit to the desired side of the spinous processes. A careful subperiosteal dissection of the muscles from the

spinous processes prevents bleeding and undue maceration of the paravertebral muscles. The muscles may be retracted laterally by a Balfour retractor which has had the teeth on one side shortened or by a modified self retaining thyroid retractor. After excising the ligamentum flavum, the lamina may be easily removed with a goose neck rongeur or a Kerrison punch. After dealing with the lesion, the dura mater should be closed tightly as for any laminectomy. The application of a centimeter strip of fibrin foam soaked in thrombin over the line of suture will tend to prevent bleeding into the angle between the spinous processes and the dura mater when the muscles are allowed to fall into place. This same space may be more nearly obliterated by placing a deep suture through the muscle and the interspinous ligament at the base of the spinous process.

Following a hemilaminectomy for a neoplasm or foreign body within the spinal canal, or a chordotomy, the patient may be allowed out of bed in three to four days. No ill results have been seen following this procedure and the patients appear to have a much better convalescence. If an intervertebral disk has been removed, the period of bed rest is prolonged to ten days.

SPINAL PUNCTURE

ADRIEN VERBRUGGHEN, M.B., Ch.M., M.S., F.A.C.S.*

It may seem presumptuous to discuss this standardized and simple procedure, but clarification of its advantages and disadvantages may not be without merit. In the last few years its use has become extended but its difficulties, dangers and fallacies are rarely mentioned. The puncture itself may be simple or difficult depending, to a great extent, on the technic used in doing it. In suitable cases its early use provides valuable information whereas in other cases it is strongly contraindicated. It may be of interest to the general practitioner to review the subject from a purely practical standpoint.

The indications for spinal puncture fall under two headings, diagnostic and therapeutic.

Diagnostic

- 1 To obtain spinal fluid for study
- 2 To estimate intracranial pressure
- 3 To test for spinal block
- 4 To introduce air or lipiodol

Therapeutic

- 1 To introduce sera, penicillin or anesthetic
- 2 To remove blood or irritative exudates
- 3 To reduce intracranial pressure
- 4 To perform spinal drainage

Before the spinal puncture can be made useful a good method for doing it should be described, for sometimes there is hesitation in performing spinal puncture because of previous technical difficulties, though except under peculiar circumstances it is a simple and relatively harmless procedure. There are also exceptional conditions under which it should certainly not be performed, but on the whole spinal puncture is probably performed less often than it should be.

TECHNIC AND EQUIPMENT

Adherence to a definite technic is important to prevent failure. The spinal puncture tray contains

- Sterile gloves and powder
- Old Kocher's or other hemostat
- Small rolled up gauze sponges
- Two regular gauze sponges

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- Four sterile towels
- One fine needle (hypodermic or longer)
- One 2 cc Luer syringe
- Two $3\frac{1}{2}$ inch 16 gauge semiflexible spinal puncture needles
- One spinal manometer (Ayer water manometer)
- One right angle adapter for manometer and spinal needle

The patient should be placed on his left side on the edge of a bed or table, this means the very edge. The shoulders and hips should be at right angles to the floor and the spine should be horizontal from the back of the head to the sternum. If the position of the patient is correct and uniform, all that remains to be done is to insert the needle in the midline at a right angle to the skin. If the patient is bent or twisted in some manner, indefinite variable factors must be considered in order to enter the subarachnoid space. The legs should be flexed on the abdomen, the back arched, the neck flexed and the head comfortably supported on a pillow of the proper thickness. An assistant may support and steady the patient in this position, but there should be no attempt at forcible flexion.

The back is painted with a coat of alcohol, and a coat of iodine which in turn is removed with another coat of alcohol. Sterile towels are placed, one underneath the patient, one over the buttocks, one over the lower ribs, and one over the loin, leaving a rectangular sterilized space from about the beginning of the sternum to the second lumbar vertebra. It is, of course, presumed that the operator's hands have been rendered sterile and that sterile gloves are worn.

The ideal place for the lumbar puncture is between the fourth and fifth lumbar vertebrae which is, as a rule, at the level of a line joining the upper parts of the iliac crests. The space between the spines is felt for with the thumb of the right hand and a thumbnail mark is made at this level. The spinous process above the mark is grasped between the finger and thumb of the left hand and another thumbnail mark is made in the midline. The cross thus made indicates the site of the puncture. The patient is then warned that he is to be touched with a needle and a wheal is raised with a fine needle and 1 per cent novocaine in a 2 cc Luer's syringe. Novocaine may also be injected along the proposed path of the spinal needle.

A semiflexible 16 gauge spinal needle is now introduced. Both hands should work together when introducing the spinal puncture needle, and the point of the needle should be controlled so that, if there is a sudden lack of resistance, the needle will not rapidly advance and travel too far across the subarachnoid space. The skin of the back is stretched tight with the forefinger and thumb of the left hand and the needle is grasped in the right hand between the forefinger and middle finger with the thumb on the hub. The back of the wrist and forearm of the operator are steadied against the patient. The needle is inserted at right angles to the skin and is gradually advanced horizon-

tally in the midline and in a slightly cranial direction. If the needle is introduced strictly in the midline, the procedure is relatively painless. Should there be any uncertainty about the needle being in the midline, ask the patient on which side he feels it, suitable adjustment can then be made.

As the ligamentum flavum is approached there will be a characteristic rubbery denseness opposed to the point of the needle which when penetrated will be followed by a little sharp click as the point of the needle passes through the tense dura mater. This little click is often described as the characteristic feature of the lumbar puncture, but probably the dense rubbery resistance of the ligamentum flavum is more constant. The stylet should be withdrawn at frequent intervals, there is no necessity to pass the needle into the subarachnoid space in one clean sweep. If the procedure is carried out carefully, slowly and methodically, the patient will sustain little or no mental or physical damage. If spinal fluid fails to flow or having started stops flowing the needle should be rotated on its long axis. Nerve roots may float up against the bevel. When the stylet is first removed one can obtain a very rough idea of the amount of spinal fluid pressure. If the fluid squirts out of the needle, one should be extremely cautious about letting further fluid escape. It is usually safer to perform the puncture with a fine but not too flexible needle if one has any notion that there will be increased intracranial pressure. Under ordinary circumstances 10 cc. of clear spinal fluid is withdrawn, which is a sufficient amount for the ordinary routine tests. The needle is then withdrawn from the spinal canal and a small square piece of adhesive tape is placed over the puncture wound. The patient is then placed flat on his back in which position he remains for the next twenty four hours. The head should be kept low but the patient may turn from side to side. This routine after care is directed toward warding off spinal puncture headache, which will be discussed later.

TECHNICAL DIFFICULTIES

The method described above, if faithfully carried out, will obviate most of the difficulties connected with spinal puncture. However, there are a certain number of cases in which difficulties arise. The most common are the "dry tap" in which spinal fluid is not obtained, and the "bloody tap" in which bloody spinal fluid is found.

Dry Tap—In a dry tap one must be sure that the needle is in the subarachnoid space. If there is much pain connected with the puncture, and I realize that the word "pain" varies from one individual to another, it is likely that the needle has not been introduced in the midline. If the flexible needles obtainable today are used, it is often difficult to control their direction. This is noticeable in performing all deep injections, for instance those for trigeminal neuralgia. Flexibility in the needles was introduced to minimize breakage and to allow a

needle to pass along a hard surface which changes its direction. If there is much pain, one should inquire of the patient on which side the pain is felt, this will assist in directing the needle in the midline.

When one does not feel the various resistances in their proper order, doubts may be entertained as to whether the needle is likely to reach the subarachnoid space. Sometimes the needle meets bony resistance in which case the only thing to do is to withdraw it and reinsert it in another direction. The needle may have to be directed more acutely upwards than at other times and, certainly it is better to alter the direction of the needle point upwards and downwards rather than from side to side. If the puncture is not started in the midline, difficulty is sure to be experienced. In fat people it may be almost impossible to feel the spines and the midline and, furthermore, the longitudinal furrow in the skin is not in the midline with the patient on his side. Under these circumstances, the point of a needle may be used to get the desired information as to laterality. In obese people it is most important to keep the skin in the correct position and tightly stretched while the needle is being inserted.

Sometimes the dry tap is obtained because the needle has been pushed in too far through the subarachnoid space and into the back of the vertebra or intervertebral disk. This is particularly likely to happen in children and infants. An article has recently been written on the subject of the herniated nucleus pulposus with extrusion of disk material, as a result of trauma to the disk in spinal puncture in children. This need not be taken too seriously. If the advice about removing the stylet at frequent intervals on the way into the spine has been followed, the situation would never have occurred. At other times the needle is in the subarachnoid space and a drop or two of the spinal fluid is obtained and then it stops. This is most likely to be due to a nerve root floating up against the bevel of the needle, in which case the needle should be turned in its long axis.

Occasionally, the stylet in the needle does not fit properly and does not carry through to the very end of the bevel, in which case it is possible to have the needle plugged by skin when it is being introduced. Very rarely, indeed, the needle is introduced properly into the subarachnoid space, but no fluid is obtained because the tip of it is in a tumor. Only an experienced observer will be sure about this situation. Serial ascending punctures may then have to be employed to obtain spinal fluid. The original needle is left in place and another spinal needle is introduced at the space above and so on until spinal fluid is obtained, with the proviso that no puncture should be done higher than between the first and second lumbar vertebrae. In infants the conus medullaris lies even lower and a puncture should not be higher than between the third and fourth lumbar vertebrae. Serial punctures may be of excellent localizing value in spinal cord tumors in the lumbar region.

There are rare instances in which a dry tap is obtained because the needle cannot be introduced into the subarachnoid space. A spinal cord injury with paraplegia recently came under my care and because of progressive symptoms a spinal puncture was attempted immediately the man entered the hospital. The attempt was finally abandoned and x rays showed a complete sclerosing arthritis of the spine of the Marie Strumpell variety making puncture absolutely impossible. It should be mentioned in order to avoid giving the impression that this is a routine procedure in spinal cord injury that this man had an extradural hemorrhage of the spinal cord which was successfully removed. Spinal cord injuries are not usually subjected to x ray pictures or other manipulations immediately after entering the hospital.

Bloody Tap—When the spinal puncture needle is introduced bloody spinal fluid may be obtained and especially if there has been some difficulty with the puncture the practitioner may be unable to decide whether the blood is due to trauma secondary to the puncture or whether it is due to the underlying conditions for which the puncture was done. The usual procedure employed is to collect 2 or 3 cc in each of three consecutively used test tubes. In practically all bloody taps in which the blood was due to the trauma of the puncture the fluid gradually clears of blood so that clear or almost completely clear fluid is obtained in the third test tube. This is usually the criterion for deciding whether the blood is due to the puncture or not. On the other hand when the blood is intimately mixed with the spinal fluid and has been for some time the three test tubes contain equal amounts of blood. In rare cases so much blood is produced in the spinal fluid by the puncture that information at this interspace is of no value. A puncture may be attempted at a higher space but if blood is found here the procedure should be terminated. It may be repeated in several days. Bloody spinal fluid is not of much value in the routine tests for which the puncture is done.

Extreme Flexion and Restraint—The technical difficulties of a puncture will not be materially lightened by forcibly flexing the patient's head and legs. This widens the space between the spinous processes but does not alter the distance to any extent between the laminae. The ligamenta flava are tough and unyielding. Intra abdominal pressure is increased with venous congestion and dilatation of the extradural veins making the chances of a bloody puncture more likely.

DIAGNOSTIC INDICATIONS

Spinal fluid is most frequently required for study for the purposes of establishing a diagnosis usually in some neurological disease for instance syphilis or encephalitis. Ten cubic centimeters of fluid are all that are required. Emphasis should be placed on the specific tests to be made on a given sample of fluid. As a rule the routine complete

examination should be done which includes *cell count, protein, sugar, chloride, Wassermann reaction and colloidal gold curve*. In consultation one frequently sees spinal fluid reports in which the fluid has been only partially examined and often the point in which one is most interested has been neglected. This is frequently the total protein. Merritt and Fremont-Smith have written a very exhaustive book on the study of cerebrospinal fluid and any matter concerning the chemical analysis or the clinical significance of the analysis will be found described in this monograph.

Spinal puncture may be performed to obtain an *estimate of the intracranial pressure* and it is most important to state emphatically that *an estimation of the spinal fluid pressure cannot be made without the spinal fluid manometer*. Practitioners who have performed spinal fluid punctures all their lives may doubt this statement, but I have had the opportunity of performing many spinal punctures and I know very well that when the estimate is made and the manometer is used to check, there are so many discrepancies as to make estimation useless. As a matter of practical experience it does not work, as a matter of necessity, one may gain an impression which may happen to be right. Furthermore, the mercury manometers and other gadgets are of very little value, what is required is an ordinary straight glass tube graduated as a water manometer (that usually employed was designed by Ayer). It is best fitted with a right angle adapter which fits into the needle. Adapters with stopcocks may not work and are often a source of wrong information especially in the hands of one not familiar with their use. In general they are more trouble than they are worth. The pressure is measured in centimeters or millimeters as the fluid rises in the graduated tube and an accurate reading is obtained. Eight to 16 cm of pressure is regarded as being within normal limits. Where the pressure is found to be increased in the manometer it is wise to satisfy oneself with a very slow withdrawal of a minimum amount of spinal fluid, say from 5 to 7 cc. If the pressure is very high say 30 cm or more, the needle should be withdrawn. More will be said on this point in the discussion of contraindications. Recourse to spinal puncture to check for increased intracranial pressure should probably be made sooner and more often in patients in whom a brain tumor is suspected. We frequently see patients with persistent headache over a short period of time say three or four months, who finally develop a well defined choked disk. A spinal puncture at an early date would have determined whether this was due to increased intracranial pressure or not. Under these circumstances with a correct diagnosis early established it is possible to perform better surgical procedures for brain tumor.

It may be necessary to obtain the *Ayala index* which is supposed to be of some differentiating value between a tumor and a communicating hydrocephalus, for instance otitic or meningitic hydrocephalus.

The equation for the index is $\frac{Q \times F}{I}$, where Q is the number of cubic centimeters of fluid withdrawn (usually 10 cc), I is the initial pressure and F the final pressure. An index of under 5 is in favor of tumor and of over 65 of hydrocephalus.

The test for spinal block is frequently necessary. * It is used for instance in spinal cord injuries to determine whether operative procedure should be contemplated and also in cases of paraplegia with a sensory level in which a spinal cord tumor is even a faint possibility. Most cases of transverse lesions with a spinal block require early operative interference. Even in rapidly oncoming paraplegias like the rare cases of extradural spinal abscess, a block may be found at an early date, and when followed by intervention the patient's chances of walking may be greatly enhanced. It may be repeated almost categorically that a spinal block indicates the necessity for a surgical intervention and it should therefore be tested early in suspected cases.

In the test for block the puncture is done in the usual manner and the spinal manometer is attached. The level at which the fluid comes to rest in the manometer is noted and preparations are made for bilateral pressure on the jugular veins. The patient is warned that when the pressure is applied to his neck he is not to resist or to hold his breath. At a given signal from the operator the jugular veins are compressed on both sides. If there is no spinal block, the fluid immediately begins to rise and continues to rise rapidly up to a certain point. At another signal from the operator the pressure is released and the spinal fluid immediately begins to descend and it goes down practically to the same level as the initial reading. This should be repeated two or three times. If there is a block or a partial block, the spinal fluid either starts to rise very sluggishly or does not rise at all. Furthermore, in cases of partial block the return of the fluid down the tube after jugular pressure is released may be very slow and incomplete. In complete block there is practically no movement whatever of the spinal fluid. The arterial pulsations one sees in the normal patient are absent when there is a spinal block but the respiratory excursions of the fluid may be exaggerated. Here again it is important to bear in mind that the nerve root may float up against the needle when jugular pressure is applied.

Spinal puncture may be employed also to introduce lipiodol, air or pantopaque for diagnostic study. As a rule these procedures will be carried out only by the neurologist or neurological surgeon and little need be said about them except that the use of air, lipiodol, pantopaque and novocaine for spinal anesthesia should be limited to those who are familiar with the technique and especially with the difficulties and dangers connected with the use of these substances. Lipiodol, for instance, is very irritating and if introduced into the spinal canal may

* The test is often referred to as the 'Queckenstedt test'. There is rarely complete understanding of the terms 'positive' and 'negative'. Queckenstedt. It is my opinion that proper names should be eliminated as much as possible in medicine, and be replaced by descriptive terms. The term spinal block could scarcely be misunderstood, besides Hilton described the anatomical mechanism of the test sixty years before Queckenstedt applied it.

make a great deal of trouble not only for the patient but for the practitioner. The introduction of air into the spinal canal for cencephalography is by no means a simple procedure and if done in unselected cases may lead to disastrous results. Pantopaque is a new radiopaque substance which is withdrawn from the spinal canal after it has served its purpose. It is usually introduced to make a diagnosis of a herniated intervertebral disk. Its use may be extended, as time goes on, for it is a relatively nonirritating substance.

THERAPEUTIC SPINAL PUNCTURE

Contrary to the usual idea, a therapeutic spinal puncture has a rather limited usefulness *to relieve increased intracranial pressure*. The puncture may be done for the above purposes in cases of head injury or in cases of a leaking intracranial aneurysm. It should not be done in either case without the use of a spinal manometer, for no accurate estimate can be made of the degree of increased intracranial pressure without this instrument. When bloody spinal fluid is obtained through the needle, the pressure is read on the manometer, the three test tubes are partly filled with spinal fluid, according to the methods described, and it is found to be equally bloody in all three of them. Having removed 10 cc of spinal fluid the pressure is again estimated. It is usually not wise to diminish the pressure by more than half. In other words, if the spinal fluid pressure is 30 cm, it should not be reduced to below 15 cm. The spinal fluid is slowly withdrawn until the desired reading is obtained. High spinal pressure should not be reduced in cases in which the fluid does not appear pathological in the first place, for the underlying reason for the increased pressure may be a brain tumor. It is usually safe to reduce increased intracranial pressure in spinal fluid which is cloudy as in meningitis, or bloody as in head injury or leaking intracranial aneurysm. Clear colorless spinal fluid under increased pressure should not be withdrawn except very slowly and in very small quantities. Under no circumstances should jugular pressure be applied in cases of increased intracranial pressure.

A spinal puncture may be performed not only to reduce increased intracranial pressure, but also *to remove irritative exudates* as, for instance, in meningitis. It has been shown that if these exudates remain too long in contact with the arachnoid and pia mater, adhesive processes may result along the base of the brain and the spinal fluid circulation may be slowed up to the extent of producing some degree of hydrocephalus which, in turn, may be the cause of further disability later on. For this reason spinal fluid is withdrawn in the leaking intracranial aneurysm where the blood is regarded as an irritative substance likely to cause adhesive reaction. It is hard to see how the amount of blood which can be withdrawn during any one spinal puncture could materially affect the formation of these adhesive processes. In the normal adult there are between 120 and 180 cc of spinal fluid. All of

this fluid becomes intimately mixed with the irritating substance and the removal of 20, 30 or even 40 cc twice a day would scarcely materially effect the irritative reaction of the pia mater and arachnoid. The spinal puncture may be employed to introduce sera or other therapeutic agents into contact with meninges or the subarachnoid space. The method has long been used in certain types of meningitis and it has been found lately that penicillin to be effective in the nervous system must be introduced by this route. Little explanation is necessary on this score. Very rarely spinal fluid drainage is indicated and it is part of the regimen that was once suggested for dehydrating patients with headache and dizziness following head injury.

CONTRAINDICATIONS TO SPINAL PUNCTURE

The most important contraindication is *increased intracranial pressure not associated with blood or pus in the spinal fluid*—in other words, due to an intracranial expanding lesion such as a tumor. When ever this possibility is considered the optic disks should be examined and if they do not appear normal a spinal puncture should not be done. This point has been labored ad nauseum but it is not sufficiently observed. The puncture of patients with increased intracranial pressure due to tumor leads to very bad results, and sometimes to immediate death.

In quite a few cases I have seen children with cerebellar tumors punctured by an enthusiastic resident or intern. Strange as it may seem in only one case was this followed by death. The point is that theoretically it could have happened in all of the cases and it should never have been done. The mechanism of death is the sudden release of pressure below and the herniation downward of the cerebellar tonsils and the medulla oblongata into the foramen magnum. It is well known that in patients with increased intracranial pressure the cerebellar tonsils are pushed down below the foramen magnum and the indentation caused by the foramen is a common sight at operation. However if such a patient were to have a spinal puncture with a sudden release of the cerebral spinal fluid from below, there is a very great possibility that the tonsils and the medulla would drop rapidly into the foramen magnum and cause a respiratory death in a few minutes.

I have seen the mechanism work in children and in adults with dramatic rapidity even in the absence of a spinal puncture. I went to visit one young patient on the morning before a cerebellar operation and found him alert but vomiting. I went to look at the chart and when I came back the nurse told me that he had stopped breathing. Immediate ventricular puncture, artificial respiration and various forms of stimulating medication failed to restore his breathing. At postmortem examination an astrocytoma of the cerebellar hemisphere was found with a marked foraminal herniation of the tonsils and the medulla oblongata.

This is by no means an isolated example. If clear spinal fluid is obtained and the pressure is high over 30 cm I believe the safest thing is to discontinue the procedure immediately. Such a patient should be in a place where immediate neurosurgical intervention could be carried out. I have often wondered what I would do if the emergency occurred to me while doing a spinal puncture and

I decided that I would have at hand sterile salt solution which I would immediately forcibly introduce into the spinal canal—that is about 10 or 15 cc of it. At the same time the foot of the bed or table should be raised. That, of course, would only be a proper plan if it immediately succeeded, for actually the only thing that can be expected to help under the circumstances is an immediate ventricular puncture with the release of pressure from above. This means shaving the head and putting a burr hole in the parietal region. However, as I mentioned before the outlook once the condition has started is extremely poor. Do not proceed then if there is clear fluid and a markedly increased intracranial pressure. Under no circumstances compress the jugular veins of patients with increased intracranial pressure.

Surgical shock is a contraindication to puncture. It may seem unnecessary to mention this, but in my experience patients are frequently seen in surgical shock with head injuries in whom a spinal puncture is being done to obtain information which is not important at the moment. Patients with head injuries suffer from a form of surgical shock and any interference with them in this condition is unwarranted. Spinal puncture, harmless as it may seem, can only contribute to the depressed condition of the patient and the information obtained during surgical shock is of relatively little value.

Spinal puncture should not be done on patients with *spinal fluid leaks*, especially those associated with skull fracture. The withdrawal of fluid through the needle may reverse the flow of fluid which is escaping from the ear or nose. Though this is only temporary, fluid may return to the subarachnoid space which has been in contact with unsterile external tissues. In the case of the nose the tissue may be laden with bacteria. Before the days of the sulfonamides meningitis was a much dreaded disease. Certainly a therapeutic spinal puncture could not be needed in such a case.

SEQUELAE OF SPINAL PUNCTURE

By far the commonest of these is *spinal puncture headache*. It is thought to be due to leakage of spinal fluid through the dura into the extradural tissues. Special needles have been devised to perform spinal puncture in which a large bore needle is used down to the dura and a small bore needle is introduced through the dura. They fit into one another in a special manner. Spinal puncture headache is said to occur very much less following the use of this instrument. Special methods of introducing spinal puncture needles have been employed and various hints have been given about not turning the needle in its long axis. This turning is said to enlarge the hole in the dura thus causing a spinal fluid leak. It is not at all clear that this is the mechanism of spinal puncture headache for it is a rare complaint in those with pathological spinal fluid. It nearly always occurs in individuals with normal spinal fluid who have had the spinal puncture done for diagnostic purposes. Patients with syphilis and other organic disease rarely

complain of spinal puncture even when they have their spinal puncture and twenty minutes later are on their way home

One of the characteristic features of spinal puncture headache is that the patient has it only when the head is raised and has no headache with the head lowered. This change is practically instantaneous. When the headache occurs the usual procedure is to keep the patient flat for twenty-four hours after the puncture without a pillow, he is allowed to turn from side to side, but he is not allowed to raise the head. The head of the bed is gradually raised over a few hours until the symptom disappears. There is no special treatment employed for persistent spinal puncture headache, except to keep the head lower than the feet and gradually to elevate the head of the bed until the headache is gone. This may take several days. A grain of codeine and 10 grains of aspirin every four hours will relieve the majority of the patients.

Another sequela of spinal puncture is the occasional *exacerbation of symptoms* in the patient with a spinal cord tumor in whom the jugular veins have been compressed in a test for spinal block. Some spinal cord tumors lie loosely in the subarachnoid space and when the pressure is increased they may be forced down into a new position causing traction on nerve roots which increases the pain. When symptoms are accentuated in such cases it tends to confirm the diagnosis of a spinal cord tumor.

FALLACIES OF LUMBAR PUNCTURE

Little has been said in the literature of the possibility of the *wrong interpretation of findings in performing tests for spinal block* and yet it frequently happens. The surgeon should always be present when spinal block is being tested for, unless he can absolutely rely on the person doing it for him. A common mistake is stating that there is not a block when there is one. This results from a mechanism which I shall describe.

We shall assume that the patient actually does have a spinal block and the needle is in place and the procedure is being employed to ascertain the presence of block. As the operator's assistant compresses the jugular veins the patient strains, holds his breath and bears down. On account of the arrangement of the abdominal veins, thoracic veins and extradural veins the pressure within the spinal canal is raised and the fluid in the manometer rises, and the interpretation is that there is not a spinal block. The patient should be warned not to bear down, hold his breath or strain at the time when the neck is grasped or a *false negative* result may be obtained. A *false positive* result may be obtained if at the moment jugular pressure is applied, a spinal nerve root floats up against the end of the needle, the fluid would then fail to rise in the manometer.

When there is especially if the obtained, anything up in the cervical

region the total protein is not likely to be so conspicuously raised, but an elevation of from 100 mg to 200 mg per 100 cc could be expected. The normal total protein is from 20 to 40 mg per 100 cc. When there is a discrepancy between the total protein and the spinal fluid block the puncture should be repeated. Incidentally, the total protein is technically difficult to estimate and unless the technician who does it is well informed on the subject, erroneous results are likely to be obtained here also.

Another fallacy connected with lumbar puncture is that in connection with estimating *lateral sinus thrombosis*. The superior sagittal sinus empties much more completely, as a rule, into the right lateral sinus than into the left, so that in the normal individual, when the right jugular vein is compressed, there is a much more prompt and complete rise than when pressure is applied to the left jugular vein. There are anatomical cases in which the left lateral sinus is very small and it is conceivable that such a patient might have a thrombosis of the lateral sinus in which, if this test were employed, a wrong impression would be obtained. It is true that the otolaryngologist would never rely solely on jugular compression to form a diagnosis, so that there is little chance that this anatomical peculiarity would be of much significance.

Another fallacy is that of trying to estimate increased intracranial pressure *without the manometer*. If this notion is persisted in, your guess is as good as mine, and it is only a guess. It is true that for many years estimates have been made of increased intracranial pressure without the spinal manometer, but there are a large number of cases in which the characteristic squirting of the fluid is not obtained and yet the pressure is increased. Much more accurate and responsible results will be obtained by using a spinal fluid manometer.

CISTERN PUNCTURE

Under exceptional circumstances it may not be possible to enter the subarachnoid space in the lumbar region and recourse will be had to the cisternal route. The method is particularly applicable in institutions and in elderly patients in whom periodic examinations of spinal fluid are required. It is actually easier in elderly persons, by one experienced, to introduce the needle into the cistern. At other times the cisternal route may be used to introduce lipiodol, sera or penicillin. I believe that it best not be attempted by those unfamiliar with the method.

The procedure, in brief, is to place the patient on the left side with a pillow or sandbag under the head so that the spine is absolutely horizontal from the occipital protuberance to the sacrum. The neck is bent slightly forward. The deepest point in the midline between the second cervical spine (the first cervical vertebra has only a rudimentary spine and no intervertebral disk) and the external occipital protuberance is identified in the midline of the neck. A wheal is raised with novocaine followed by infiltration of the deeper tissues of the *ligamentum nuchae*. The direction of the puncture is from this point in the midline to a plane joining the roofs of the orbits. A heavier and stiffer needle than that used in the spinal region is advisable. It is carefully introduced in the midline in the direction described until the characteristic pop of the dura is obtained or until spinal fluid is obtained. Bony resistance may be met and the needle point

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False negative results can be checked against the total protein. When there is a spinal block the total protein of the spinal fluid is raised especially if the block is low in the canal. A very high total protein may be obtained anything from 200 mg to 2000 mg per 100 cc. When the block is higher up in the cervical

THE TECHNIC OF THYROIDECTOMY

WARREN H. COLL, M.D.*

ANATOMY

The thyroid gland consists of two lobes joined by an isthmus from which a small projection called the pyramidal lobe usually extends upward. The lobes are attached to the anterior and lateral aspects of the larynx and upper trachea. The isthmus overlies the second and third tracheal rings. Except in thin persons, the normal thyroid is not palpable. Proceeding from the skin posteriorly the structures overlying the thyroid are skin, fat, superficial fascia, platysma muscle, deep cervical fascia, sternothyroid and sternohyoid muscles. The carotid sheath lies just posterior to the lateral edge of the thyroid which projects against the inner border of the sternomastoid muscle. A capsule of variable thickness extends around the thyroid. The gland is held in position somewhat by the suspensory ligament which attaches the capsule to the thyroid cartilage.

The blood supply of the thyroid gland is provided by the superior and inferior thyroid arteries and the thyroid ima artery which sends branches to the medial border of each lobe. These branches are not constant. The superior thyroid artery arises from the external carotid artery and pierces the superior pole of the gland where it divides profusely. The inferior thyroid artery arises from the thyroid axis. It usually divides into two main branches before piercing the gland. The veins are numerous, the most important one being the middle thyroid vein which empties into the internal jugular vein. The middle thyroid vein is frequently not recognized and when torn can give rise to an enormous amount of troublesome bleeding.

Perhaps the most important adjacent structures are the recurrent laryngeal nerves which arise from the vagus nerve. On the right side the nerve proceeds downward, loops around the subclavian and then continues upward into the groove between the trachea and esophagus lying adjacent to the posterior capsule of the thyroid. On the left side the nerve proceeds downward, loops around the aorta and then continues upward into the tracheo-esophageal groove. The relationship of the laryngeal nerves to the fork made by the branching of the inferior thyroid artery is variable. Berlin and Lahey¹ noted that in eighteen of twenty-three cadavers the nerve on the right was anterior to the ar-

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may have to be depressed or elevated according to whether contact has been established with the occipital bone or the arch of the atlas. The main thing is to introduce the needle slowly with the patient relaxed and the head slightly flexed removing the stylet at frequent intervals. There is actually about a half an inch of space between the dura mater and the posterior aspect of the cerebellum in the cisterna magna, the point at which the needle will enter the subarachnoid space. Care and caution are the two things which are required to do this successfully, provided the position of the patient is maintained as described.

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thetic when cardiac damage is present, particularly if there is a history of irregularity.

The patient is placed on the table with a small pad behind his neck. In my opinion, this position presses the thyroid forward and makes dissection easier without interfering with the airway or anesthesia. The head should be held straight, avoiding rotation. Lifting the chin upward or rolling the head backward improves exposure somewhat and appears to improve the airway. I prefer to have the head and chest of the patient elevated.

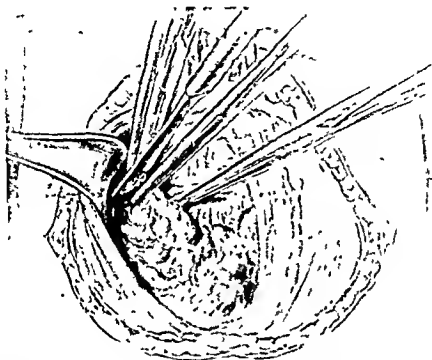


Fig 63.—With the neck extended on the operating table the incision must be high to keep it from retracting onto the thorax when the normal position is assumed. The muscles are split in the midline and retracted to expose first the right lobe. The thyroid ima vessels and the superior vessels are ligated and cut as shown.

The incision should not be made until the patient is completely under the anesthetic. Premature incision may give rise to laryngeal spasm which may become severe enough to require intubation. The anesthetist should be prepared at all times to do an intubation at a moment's notice in case severe laryngeal spasm develops or one or both recurrent nerves are injured.

Subtotal Thyroidectomy.—A collar incision is made, beginning at the edge of the sternomastoid and extending from one side to the other about 2.5 cm. above the upper margin of the clavicle. When the patient assumes a normal position, the scar of this incision will be lo-

cated just over the suprasternal notch so that it can be hidden by a string of beads. The incision is made through the platysma muscle, exposing the deep fascia, but must not be so deep as to sever the anterior jugular vein or its major branches. The upper skin flap must be dissected from the deep fascia upward at least as high as the thyroid notch. This can be done by sharp or blunt dissection although in most cases blunt dissection by a finger or thumb covered with gauze will rapidly mobilize the flap. The lower flap must be undermined down to the suprasternal notch. Without this undermining, exposure will be poor and an easy approach may be difficult. The deep cervical fascia

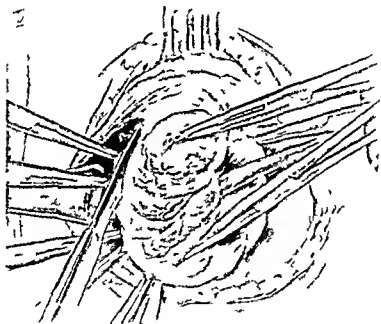


Fig. 64—After the vessels in the posterior capsule are controlled by numerous clamps the gland is amputated keeping the line of incision close to the posterior capsule lest too much thyroid remain.

is split in the midline the incision being made between the anterior jugular veins in order to avoid bleeding. If the incision is carried down toward the suprasternal notch it may cut across one of the veins since they frequently converge at this point. If the two veins join high one will have to be ligated in order to allow sufficient extension of the incision downward to the suprasternal area. Care should be taken when cutting tissue within this region to occlude incised veins promptly so that air embolism will not develop. It is well to ligate bleeding points incurred during dissection before the thyroid is mobilized.

The sternothyroid and sternohyoid muscles are then separated from

the thyroid lobes by blunt and sharp dissection. Both lobes may be mobilized before either lobe is dissected, although mobilization may be done as each lobe is approached. After the muscles are dissected from the thyroid they can be retracted laterally to afford sufficient exposure, particularly if retraction is limited to one side at a time.

If the gland is large or the upper pole extends high up behind the ramus or the mandible, it may be desirable to section the sternohyoid and sternothyroid muscles transversely, although I rarely follow this procedure. If this is done the muscles should be cut at a high level in order to preserve nerve supply. I prefer to insert the Ochsner for-

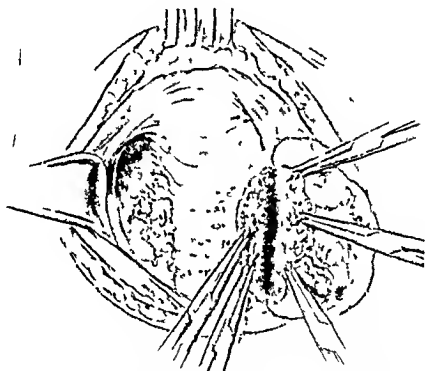


Fig. 65—The right lobe has been removed the isthmus dissected from the trachea and the left lobe dissected from the lateral surface of the trachea by sharp dissection as illustrated.

ceps from the lateral side toward the midline. When this is done, the handles of the forceps fall back out of the operative field and are not constantly falling forward into the field. Cutting these ribbon muscles when exposure is difficult will prevent strenuous traction which is harmful to the tissues. If it is difficult to expose the posterior surface of the gland because of fixation or some other complication, section of the muscles is strongly indicated. After the muscles are cut, both ends of the anterior jugular vein should be isolated and ligated before the wound is closed.

Muscle fibers and the capsule are stripped from the thyroid from the medial toward the lateral side, with the finger covered with gauze.

Application of forceps to the lobe will usually allow sufficient mobilization anteriorly to expose the gland and the superior thyroid vessels. With a blunt nosed Pean hemostat the upper pole is isolated, clamped and doubly tied. I prefer cotton for all ligatures, using a No. 20 cotton for the superior and inferior thyroid artery and No. 40 or 60 for the rest of the vessels. Double ligation of the two main arteries may prevent disaster in case one suture slips or comes untied. After the superior thyroid pole is ligated, the lobe is rolled forward, and the remaining attachment of the upper pole is clamped with a Pean hemostat allowing the entire upper portion to be rotated anteriorly and medially. I then ligate the ima vessels, dissecting toward the midline and exposing a small portion of the trachea. This exposure of the trachea will be found most advantageous in determining the direction of the cut through the base of the gland with the scalpel as the trachea is approached. Only a few hemostatic clamps should be allowed to accumulate in the wound because their weight may impede the patient's breathing, furthermore if a large vessel should be opened, it is frequently difficult to control hemorrhage when several hemostats are in place around the bleeding point.

The lateral portion of the lobe and the lower pole are then mobilized by blunt dissection, and the lobe is gently rolled toward the midline to expose the posterior tissues. Frequently, particularly in nodular glands, large projections of thyroid tissue will be encountered posteriorly. These may be left until exposure of the posterior capsule is obtained. It should be emphasized, however, that this rotation of the lobe should be performed gently and no instrumentation should be allowed along the posterior capsule that might injure the recurrent nerves or the parathyroid glands. Dissection along the lateral border will expose the middle thyroid vein which should be isolated, clamped and tied. All vessels along the lateral and inferior edge of the thyroid lobe are clamped by taking bites in the capsule at frequent intervals. For this purpose Ochsner forceps are preferable since they will not tear out as readily as other smaller forceps. On other occasions, I wish to stress the advisability of using small forceps wherever possible to avoid trauma. After this row of hemostats is placed in position the lobe is amputated by incising it with a knife from the lateral edge toward the trachea. If there is some doubt about the depth of the cut the knife blade may be guided by the index finger placed posteriorly against the posterior capsule. On certain occasions when the posterior capsule is thick and a fairly complete thyroidectomy is desired, blunt dissection and cutting with a curved Mayo scissors will allow a more complete thyroidectomy with added safety.

At no time should the posterior capsule, particularly near the midline and the lower portion, be included in a hemostat bite, unless the recurrent nerve has already been isolated and is not in the way. As a rule I do not isolate the recurrent laryngeal nerve unless the nodules

seem to project in that region or some other anomaly is present. It is surprising how readily the nerve may be injured with a clamp unless it actually is dissected free from the adjacent tissue. Naturally, any dissection of the nerve must be done carefully to avoid trauma and temporary paralysis.

Hemostats are placed on the thyroid tissue and on vessels as they are encountered to prevent the wound from being flooded and obscured by blood. After the inner edge of the lobe is cut across, the trachea will come into view. This cut through the thyroid toward the midline can be made with more safety to the trachea if the trachea is

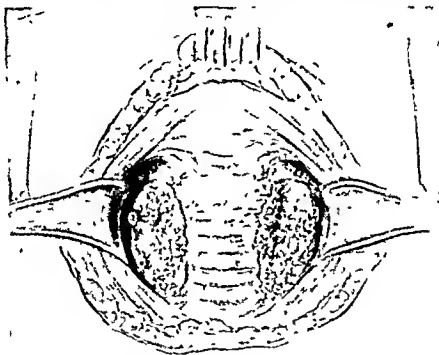


Fig 66—Appearance of neck after subtotal thyroidectomy for toxic diffuse goiter. Note that 2 or 3 gm of tissue remain on each side after removal of the thyroid lobes. The edges of these amputated surfaces may or may not be inverted with interrupted sutures

exposed for a short distance under the isthmus before the incision through the lobe is started. By sharp or blunt dissection the trachea is separated from the isthmus, and all vessels are tied on that side of the operative field. Suture together of the two edges of the remaining thyroid tissue will improve hemostasis if any oozing remains. Some surgeons suture the lateral edge of the remaining thyroid tissue to the trachea but I rarely resort to this practice unless the fixation can be accomplished without any danger of injury to the trachea wall. If bleeding is very profuse in the remaining tissue, ligation of the inferior thyroid will be indicated. It will be found by continuing dis-

section posteriorly. When the ligature is placed, care must be exercised not to include the nerve. Care of the thyroid bed as just described is usually left until the left lobe has been removed.

Methods for removing the left lobe differ somewhat, but I prefer first to ligate the superior pole and then to dissect the lobe from the trachea by sharp dissection. As the region of the recurrent laryngeal nerve is approached, the thyroid capsule is left in position by cutting through this area with a knife. Ochsner forceps are then applied to the capsule on the lateral and inferior sides, preparatory to amputating the lobe. The cut is made here in a way similar to that described on

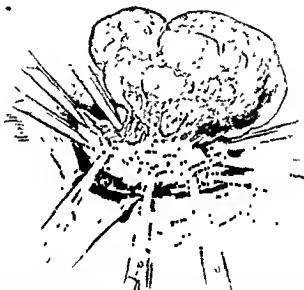


Fig. 67—Removal of an adenoma in which all of the thyroid tissue is excised. The artery forceps control all the bleeding points but with sharp dissection the entire adenomatous lobe has been removed from its capsule thereby leaving no thyroid tissue. The nerve is shown well inferior to the operative field but may be displaced to almost any nearby position by an adenoma.

the right side, leaving the posterior capsule and two to four grams of thyroid tissue, depending upon the type of gland. In general, patients who are extremely toxic but have small glands should have no more than 1 or 2 gm. of thyroid tissue left on each side, while patients who are only mildly toxic and have large glands may have 4 to 6 gm. of thyroid tissue left on each side without danger of recurrence of symptoms. In toxic nodular goiter there is much less tendency to recurrence but effort is usually made to make a fairly complete excision of the degenerated thyroid tissue.

In my opinion, cotton is preferable to silk or catgut for ligatures. The incidence of infection is much lower with cotton than with cat-

gut It is true, however, that if infection develops, sinus formation may be prolonged because of the presence of nonabsorbable sutures, some of which may be extruded However, this complication has not been of consequence in my experience It is important not to place ligatures close to the skin, since they will tend to work toward the surface Bleeding points in the skin and subcutaneous tissue on the flap immediately adjacent to the skin can be controlled by taking deep bites with the skin suture or large bites with skin clips, depending upon which are used

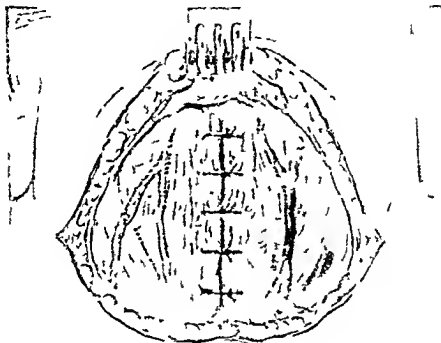


Fig 68—The ribbon muscles are approximated in the midline by interrupted sutures Complete repair as illustrated is important because the skin may adhere to the trachea if muscle is not interposed, adherence of skin to the trachea is a troublesome complication which usually requires operative correction If cotton or silk is used (as recommended by the author) a drain is not necessary

Complete Thyroidectomy—There are three indications for a complete thyroidectomy, at least on one side (1) large unilateral or bilateral adenomatous glands without normal thyroid tissue to the posterior surface, (2) any toxic diffuse goiter in which considerable cardiac damage is present, and (3) carcinoma

Toxic Nodular Goiter—When the adenoma is located on one side and occupies practically the entire lobe, the thyroidectomy is usually made complete on that side When there is considerable elastic and loose fibrous tissue associated with the posterior capsule, the lobe may be resected so far from the neighborhood of the recurrent laryngeal

nerve that isolation of this structure will be unnecessary. Even then clamps applied to the posterior portion of the gland should be placed close to the gland itself so that the nerve cannot possibly be injured even if it is pulled upward in the fibrous tissue with the thyroid lobe. If the thyroid lobe is anchored fairly firmly adjacent to the trachea and esophagus, dissection must be made carefully in this region, and the nerve must be identified before the lobe is removed.

When both lobes of the thyroid are involved in the nodular degeneration, bilateral total thyroidectomy may be indicated, particularly if no tissue resembling normal thyroid can be seen on the posterior surface. If all of the gland is degenerative, there is no reason for leaving any of it since it would probably have no thyroid function anyway. A complete thyroidectomy therefore may be the procedure of choice. Leaving a few grams of tissue can do nothing more than protect the surgeon against injury to the recurrent laryngeal nerve or removal of the parathyroid glands.

Toxic Diffuse Goiter with Cardiac Damage—Cardiac damage is more commonly encountered in toxic nodular goiter than in toxic diffuse goiter. However, regardless of the type of gland present, indications for complete thyroidectomy are fairly definite if the cardiac lesion is more than a temporary and insignificant one. The purpose of performing total thyroidectomy is to produce hypothyroidism thereby diminishing the load on cardiac function. The complete thyroidectomy is performed somewhat as described above; it is usually advisable to isolate the nerve unless as mentioned previously, the lobe can be resected from its bed without the possibility of pulling the nerve forward into the field. Certainly the adoption of identification of the nerve before the excision of the lobe in a total thyroidectomy is a safe procedure and will unquestionably eliminate many instances of injury to the nerve. Since patients in whom such a complete operation is contemplated are practically always in the latter decades of life the need for preservation of parathyroid glands is not so acute. It is well known that complete thyroidectomy can be performed in such patients with an extremely low incidence of parathyroid tetany. When tetany occurs, it is practically always mild, and it responds well to dihydrotachysterol milk and calcium.

Carcinoma—Complete thyroidectomy and a neck dissection will be indicated when carcinoma of the thyroid is present. Unfortunately, many cases will be encountered in which a definite diagnosis cannot be made before operation. However, if one recalls that carcinoma is much more common in solitary nontoxic nodules, failure to recognize the presence of carcinoma will be lessened. The degree of fixation to the adjacent tissue will help to some extent in identifying the lesion as carcinoma, but it is by no means pathognomonic since fixation can be produced by thyroiditis, including Hashimoto's and Riedel's type. Cutting into the thyroid after a lobe is removed will be of great help

in identifying the presence of a carcinomatous area. Obviously, if evidence of invasion beyond the thyroid capsule can be found, a diagnosis of carcinoma is fairly definite. When the diagnosis of carcinoma is made, a total thyroidectomy should be performed on the affected side and a subtotal thyroidectomy on the nonaffected side. The extent of the lesion will determine whether a neck dissection should be done on both sides or just one. The indications and technic of neck dissection are discussed in detail in another article in this volume.

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NECK DISSECTIONS INDICATIONS AND TECHNIQS

DANIEL P. SLAUGHTER, M.D.*

DEATH resulting from cancer arising in the structures of the head and neck is so often due to cervical metastases that this phase of the disease is of equal or greater concern than the treatment of the primary lesion. Treatment of the primary lesions has become so efficient that only the minority of treated patients die from the effects of the tumor at its site of origin or from the results of its treatment. In many cases when the primary tumor cannot be eradicated the patient may be temporarily salvaged by the classical surgical bypass of tracheostomy or gastrostomy. These expediences still condemn the patient so afflicted to succumb to the secondary deposits. It is obvious that the control of the metastatic disease is of prime importance in cancers arising in the head and neck. It may seem unnecessary to emphasize such a point but the majority of cancer patients defined as incurable at their first examination in the tumor clinic are those whose primary lesions have been treated elsewhere without adequate follow-up or consideration of metastatic involvement.

MECHANISM OF METASTASIS AND RELATION TO RATIONALE OF TREATMENT

It is apparent that early in the course of metastasizing epithelial tumors the process is one of cell embolism through lymphatics. If this were not so it would never be possible to cure a patient by obliterating a primary lesion and then removing metastatic disease in regional nodes without excision of all intervening tissue. Lymphatic permeation where lymphatics are filled with tumor cells extending from the primary to the regional nodes occurs late in the course of malignant tumors after lymphatic blockade is produced by tumor growth in nodes. This late stage is for all practical purposes incurable.

With the exception of thyroid tumors and melanomas most cancers in the head and neck confine their metastatic activities to the lymphatic pathways. Only occasionally do the usual epidermoid carcinomas arising in this region invade the direct venous return system to the lungs or gain access to the prevertebral venous system. Because of this preponderance of lymphatic metastasis in head and neck cancer most of these tumors remain confined to the region above the clavicles throughout their course, a fact which is not sufficiently appreciated. This is important because it defines the problem of treatment as one of local control of most head and neck cancer at of the spine long bones in the head and neck area it will recur in that region and kill the patient from local effects. Braund and Martin¹ in a review of autopsies on patients dying from head and neck cancer

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state that in only twenty three per cent were metastases found below the clavicles. Obviously this is because a fatal outcome in these cases occurs before the tumor had an opportunity to spread further.

Depending upon anatomic location and pathologic propensity, malignant tumors have fairly definite patterns of metastasis. Since the great majority of such lesions arising in the head and neck are primary epidermoid carcinomas in the mucosa of the upper air and food passages or of the skin their behavior is predictable within certain limits. Treatment of the metastases from such lesions depends upon a recognition of these behavior patterns. For instance we do not expect a carcinoma of the left buccal mucosa to metastasize first to a node in the right neck. Neither does a carcinoma of the lower lip usually appear first in a node low in the posterior triangle on the same side.

A distinct trend in the pattern of metastasis of head and neck tumors is their tendency to unilateral spread. The anatomy and physiology of the lymphatics confines cell embolism from an early primary lesion to one side of the neck. Bilateral cervical metastases seldom occur early unless the primary tumor extends across the midline, or until the cervical lymph nodes on one side are blocked to a degree causing reversal of lymphatic flow. Such obstruction to lymphatic flow may be due to blockade by extensive metastases in advanced cases or by surgical removal or radiation obliteration of the lymphatic system on one side. This mechanism of contralateral metastasis explains the generally accepted preclusion of regional node dissection before the primary tumor is eradicated.

There is a fairly direct lymphatic drainage from any given anatomic site to the first interposed lymph node but there are so many minute variations that only groups of nodes have clinical significance. Roughly these groups are arranged in echelons in order of metastatic involvement. These primary echelons of nodes in the neck have been described and illustrated by Taylor and Nathanson² in their book on lymph node metastases. The clinical difficulty in determining the exact extent of cervical metastatic disease, however, makes these considerations mainly of theoretic interest. For practical purposes one of the two general types of neck dissection is applied to all cases suitable for dissection. These types will be discussed below.

Of more than theoretic interest however is the fact that usually groups of nodes rather than a single node are involved by metastatic disease by the time the patient is seen as a clinical problem. This may not be apparent clinically, but examination of dissection specimens in the pathology laboratory demonstrates multiple node involvement as a rule. This factor of multiple node involvement has an important bearing on the indications for surgery or radiation in the therapy of cervical metastatic cancer.

RADIATION VERSUS SURGERY

There is no question that a single node metastasis of moderate size can be obliterated by radiation methods in a high percentage of cases. This is usually best done by a combination of external x-radiation and interstitial radiation in the form of gold radon seeds, or by the use of seeds alone. However the sterilization of a single focus of metastatic cancer is not the problem. The involvement of groups of nodes, and multiple echelons of node groups requires application of radiation to an impossibly wide area. A thoroughly cancerocidal dose of radiation cannot be delivered to one entire side of the neck because of tissue tolerance limits. To deliver such a dose of radiation in any combination of methods would result fatally. Block dissection of the neck is

the only alternative at the present time that will give a reasonable cure rate in cervical metastatic cancer

Combinations of radiation and surgery are frequently useful, and are often utilized when operable cervical metastases are present when the patient is first seen. Radiation may be used in such a situation to retard the course of the cervical disease until the primary lesion has received definitive treatment. When the primary lesion is eradicated neck dissection may be undertaken. Although it will be somewhat complicated by the preceding irradiation, it is still feasible.

The casual and irrational use of radiation as prophylaxis against cervical metastases is to be strongly condemned. There is a prevalent misconception among physicians that "a little x-ray" to the neck is a good thing in patients with intraoral or lip cancer. Nothing could be more illogical, as in patients without cervical metastases the radiation is affecting only normal tissue, and in those with metastases, even occult, the light doses used accomplish nothing, except to confuse the situation.

INDICATIONS AND CONTRAINDICATIONS FOR NECK DISSECTION

Neck dissection should be done for metastatic cancer when the metastases are clinically demonstrable, when the nodes are movable and discrete and when distant metastases are not detectable. The contraindications to neck dissection are essentially in three categories: when other pathologic conditions, such as organic heart disease, are severe enough to preclude a major elective surgical procedure, when there is clinical evidence of distant metastases such as involvement of lungs, liver or other node groups, and when the involved cervical nodes are fixed to underlying structures. It is a general rule that when metastatic disease is doubtfully operable, it is usually futile to attempt neck dissection with a reasonable expectation of cure. Worthwhile palliation may be achieved in selected instances of questionably operable lesions by implantation of radon "seeds" into residual tumor that cannot be removed.

The controversial points about the indications for neck dissection center about the *timing of the operation*. The greatest difference of

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able Kennedy⁴ concurs in this opinion and has recommended that a suprahyoid dissection be done in all cases at the same time as the lip lesion is excised. Contrary to this conception Martin⁵ believes that neck dissection should not be done unless there is definite clinical evidence that there is metastatic disease in the cervical nodes. He has presented cogent statistical reasons for his stand and has shown that prophylactic neck dissections for lip and intra

oral cancers is a great waste of time, the operative mortality equalling the potential cure rate in patients with undetected metastases. He has also demonstrated that the cure rate in patients without demonstrable neck metastases is approximately the same whether or not neck dissection is done. This last is a fairly conclusive argument against prophylactic dissection.

On theoretic grounds it would seem preferable at least to delay neck dissection until some weeks after the primary lesion is eradicated. Such an interval of time would allow cells loose in the regional lymphatics to reach the regional node filter. In most intraoral cancers the primary lesion and the regional nodes cannot be removed without leaving the lymphatics between them, and therefore the principle of "excision and dissection in continuity"⁶ cannot be achieved. The classical operation of this type is the radical mastectomy, in which the primary lesion and the regional nodes, plus the intervening lymphatics, are removed together in an en bloc dissection. Anatomically most head and neck cancers cannot readily be excised in this manner, and the lymphatics between the site of the primary lesion and the metastatic nodes must be left in place.

These last considerations explain why neck dissections should not be done until the primary tumor is eradicated by either surgical or radiation measures. Another reason against prophylactic dissection is the ever present doubt as to the complete obliteration of the primary lesion by the initial treatment.

I believe that ideally neck dissection should be delayed until there is definite clinical evidence of metastatic disease in the cervical nodes. This requires very careful follow-up and better control of the patient than is always possible. Because of this last factor, an exception may occasionally be made. A prophylactic dissection may be done for tongue carcinomas in doubtful situations. Such patients usually are clinic cases who live several hundred miles away and cannot return for adequate follow-up visits.

The operation of supraomohyoid dissection is indicated for metastases from unilateral lip and anterior face cancer and for minimal metastases from cancer of the gingiva and buccal mucosa. In well selected instances of cancer of the floor of the mouth or anterior tongue, this operation is also permissible. The radical neck dissection should be done for all patients in the above categories whose metastases are moderately advanced but still operable. In addition, all metastases first evident in the mid-neck, at the level of the carotid bifurcation or below, should be attacked by radical neck dissection, the provisions of operability being observed.

The presence of *bilateral cervical metastases* has usually been considered a contraindication to neck dissection for two reasons: first, because bilateral cervical lymph node involvement is considered by many to be incurable by any method, and secondly, because com-

plete bilateral neck dissection even in two stages has been thought impractical since it requires the removal of both internal jugular veins. Excision of both internal jugular veins is generally regarded as extremely hazardous if not invariably fatal. It has been demonstrated by Martin⁵ however that staged removal of both internal jugular veins is a safe procedure. In his clinic some thirty patients have undergone bilateral neck dissections in stages without postoperative mortality. Some of these patients have experienced a moderate, transient cyanosis and lymphedema of the face following the second stage, but there have been no systemic sequelae and no eyeground changes in any case. Martin reports one five year cure in four cases of bilateral neck dissection and five three year cures in fifteen cases. The remainder of his thirty cases are of less than three years duration, and therefore not suitable for any kind of end result reporting. From the three year figure of 33 per cent cures it is plain that the control of bilateral cervical metastases by neck dissection is possible. The exact evaluation will however depend upon the five year cures calculated on a larger series. Comparably bilateral groin dissections in carcinoma of the penis or vulva will result in a moderate number of cured patients.

Metastases from the highly malignant lesions arising in the nasopharynx and base of tongue of the so called *lymphoepithelioma* type, are not suitable for neck dissection. These tumors ordinarily produce early and widespread bilateral neck metastases but they are more radiosensitive than the average epidermoid carcinoma in the neck. Therefore irradiation methods will salvage as many or more of these patients than will bilateral neck dissection.

CURE RATES

Although cervical metastasis from head and neck cancer is often a death warrant for the patient it is by no means necessarily so. The published cure rates from the treatment of cervical metastases are no triumph of therapy but they do show that a fair number of patients can be cured by aggressive treatment of an otherwise 100 per cent fatal disease.

Martin⁵ has published a fair review of the results of neck dissections. His figures show a 26 per cent five year cure rate of histologically proved cervical metastatic cancer. This is an average figure and includes the cures of metastases from lip cancer, which are higher and those of melanomas and epidermoid carcinoma of the tongue and other areas which are much lower. Reviews by various other authors do not vary remarkably from this figure (Taylor and Nathanson⁶, Brown and McDowell,⁸ Duffy,⁹ Blair, Moore and Byars¹⁰).

Martin's most recent figures⁷ as yet unpublished are as follows:

The net cure rate in 138 unilateral neck dissections performed on the Head and Neck Service at Memorial Hospital five or more years

ago is about 30 per cent living and free of disease. For these calculations, only those cases in which cancer was demonstrated histologically in the surgical material were counted. All cases in which cancer was not found in the excised lymph nodes were excluded. The cure rate varied somewhat depending upon the site of the primary lesion. For instance, in cancer of the lip the five year cure rate following neck dissection was 33 per cent, and in the tongue 21 per cent.

TECHNIC OF NECK DISSECTION

Dissection of the lymph nodes and lymphatics of the neck can be done by one of several procedures. Most of the operations are variations of two basic procedures, which are the upper neck dissection and the complete neck dissection. Either upper or complete neck dissection may be done under local anesthesia, and until recent years the mortality rate of the operations was distinctly better with local anesthesia. With the refinement of intratracheal anesthesia and the greater availability of well trained medical anesthetists, however, I believe this advantage to be nullified. From both the patient's and surgeon's standpoint I prefer general anesthesia administered through an endotracheal tube, the usual agents being cyclopropane or nitrous oxide and ether.

Upper Neck Dissections.—The unilateral partial or upper neck dissection is the classical *submaxillary* or *suprahyoid* dissection. In this operation the Kocher incision is used, starting from the mastoid process on one side and curving downward, forward and then upward to the midline of the chin (Fig. 69, No. 1). The skin flaps are dissected above the level of the platysma muscle superiorly to a finger's breadth above the lower border of the mandible, and inferiorly to just below the level of the hyoid bone. The platysma is then incised within these limits and the contents of the submaxillary triangle excised. Essentially this removes the submaxillary gland and the lymph nodes adjacent to it, those along the facial artery and those of one side of the submental area. This operation is utilized mainly for metastases from carcinoma of the lower lip on the same side. The same procedure may be done as a bilateral dissection by carrying the incision from the tip of one mastoid process to the other, crossing halfway between the mandible and the hyoid in the midline. When removal of the nodes is indicated in patients with lip cancer this bilateral suprahyoid dissection should be done if the primary lesion extends to or beyond the midline of the lip.

The submaxillary dissection as outlined, either unilateral or bilateral, is actually an incomplete operation. It consists essentially of removal of the tissues between the anterior and posterior bellies of the digastric muscle, which has been proved to be inadequate in the light of our experience.

The *supraomohyoid* operation of upper neck dissection has sup

planted the submaxillary dissection and now is considered to be the operation of choice whenever an upper neck dissection is indicated



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In this procedure the incision is similar to the Kocher incision, except that the transverse portion of the curve extends downward to the

level of the hyoid bone, allowing for greater retraction of the inferior skin flap. The upper flap is correspondingly wider. In addition a vertical arm may be carried downward for an inch or two from the midpoint of the transverse incision (Fig. 69, No. 1). The dissection of the submaxillary and submental space is the same in this operation, the essential difference being in exposure and retraction of the sternomastoid muscle and internal jugular vein, with subsequent removal of the nodes surrounding the level of the carotid bifurcation. This dissection requires ligation and section of the common facial vein, and more care is necessary to avoid damage to the hypoglossal nerve at its point of crossing above the carotid bifurcation. The tail of the parotid gland is usually excised, sacrificing the lower branch of the facial nerve, causing weakness in the lower lip on that side. This operation may be done either as a unilateral or bilateral procedure, depending on the individual situation. The advantages of the supraomohyoid dissection are two: first, a second echelon of nodes is removed in addition to those primarily involved, which is always a wise precaution in cancer surgery. Secondly, this operation is applicable to the metastases from a wider group of primary lesions, including carcinomas of the lip, anterior half of face, buccal mucosa, gingiva, anterior floor of mouth and occasionally anterior tongue lesions. Whenever metastases are found to be moderately extensive and advanced, however, this operation should be converted into a full radical neck dissection.

2. Radical Neck Dissection—Complete unilateral dissection of the neck is an extensive operative procedure which involves removal of the sternomastoid muscle and internal jugular vein, and dissection of all triangles of the neck on one side. The operation is actually less formidable than it sounds, being essentially a formal anatomical dissection in which removal of the sternomastoid muscle and internal jugular vein are done to facilitate the dissection rather than to enhance the possibility of cure. This last is true even of vein-involving thyroid cancers, because if they have invaded the internal jugular vein, the existence of distant metastases is practically a certainty. To put it differently, complete dissection of the lymphatic tissue of the neck is extremely hazardous and difficult to the point of being impossible if these two structures are not removed.

The usual incisions for radical neck dissection are outlined in Figure 69, Nos. 3, 4 and 5. Whether to turn up the platysma with the skin flaps or remove it with the dissection specimen is probably not important. Leaving it attached to the skin possibly increases the blood supply to the skin flaps, but they heal well anyway. If excision of the platysma is required to remove the tumor, the dissection is a waste of time as the disease is too extensive to be cured by the operation. The surgical custom is to dissect the skin flaps external to the platysma, removing this muscle with the dissection specimen.

After the skin flaps are dissected back as indicated in the diagrams

the sternal and clavicular ends of the sternomastoid muscle are divided. Underlying this muscle the internal jugular vein is identified and gently teased free so that it can be divided and ligated without damage to the vagus nerve. The carotid sheath is then opened and the divided muscle and vein turned upward. The dissection is then done laterally, dividing the omohyoid muscle at the clavicle and ligating the transverse cervical and suprascapular vessels to the border of the trapezius. The brachial plexus, scalene muscles and phrenic nerve are bared and the dissection is then swept upward along the whole exposure. Laterally the eleventh nerve is the next structure of importance, and in some cases it may be saved by very careful dissection. Along the carotid sheath the dissection is straight forward up to the carotid bifurcation. From this level upward major vessels are divided and ligated as they are encountered. Frequent anomalies, particularly of the veins, are found which are difficult to describe. The hypoglossal nerve should be preserved but the ansa hypoglossi must be transected. At this level when the hyoid bone and posterior belly of the digastricus are encountered, the submaxillary space may be dissected proceeding from the inferior and medial aspect, so that this tissue mass may be removed in continuity with the main specimen. The dissection is then completed by removing the lower pole of the parotid gland and transecting the sternomastoid muscle at its attachment to the skin and mastoid process. The last step of the dissection is division and ligation of the internal jugular vein. This may often be done before the parotid and sternomastoid are cut across, particularly if there are high metastatic nodes which may necessitate an approach from the internal and medial aspect. After the specimen is removed, the skin flaps are approximated and two Penrose drains are left in place. A light pressure dressing of mechanic's waste is applied. Drainage from such wounds is usually profuse, due to the lymphorrhea and area of cut surface exposed, but I believe tissue reaction and serous exudate are minimized by the use throughout of fine cotton, Nos. 50 and 60, for all ligatures and sutures.

CARCINOMA OF THE THYROID

Malignant thyroid tumors require separate consideration because they tend to metastasize both by veins and by lymphatics, and because they often are not diagnosed clinically before, or even in the course of surgical removal. Thyroid cancers can be divided roughly into two categories, those in which the diagnosis is either obvious or suspected, and those in which the diagnosis of cancer is made only through microscopic examination of the surgical specimen. This latter group of thyroid cancers is obviously the most easily cured, but the usual subtotal thyroidectomy is not an adequate safeguard against recurrence. Cole, Slaughter and Rossiter¹² have demonstrated that this

group usually occurs in patients with a unilateral thyroid mass without evidence of hyperthyroidism. Therefore it is recommended that in the routine surgical removal of unilateral nontoxic adenomas of the thyroid, a deliberate total hemithyroidectomy always be done, with complete exposure of the recurrent laryngeal nerve to avoid its injury.

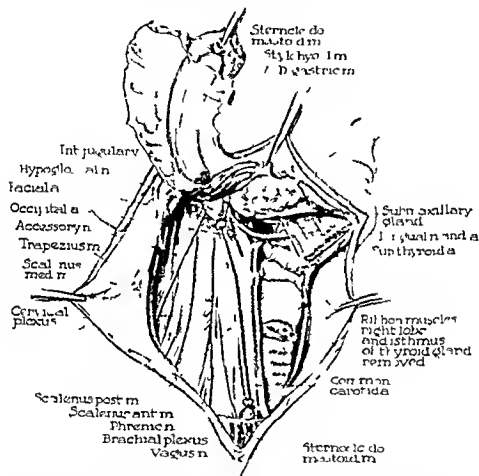


Fig 70—The end stage of the operation of radical thyroidectomy, before the posterior triangle dissection specimen is removed. The internal jugular vein is usually ligated somewhat higher than is shown here. This figure also illustrates the operation of radical neck dissection. The differences between the two operations are that the submaxillary triangle is not usually dissected in the radical thyroidectomy and the ribbon muscles and thyroid gland are ordinarily not disturbed in the radical neck dissection.

When the diagnosis of thyroid cancer can be made clinically or verified at the operating table, the disease is more extensive, and a more radical surgical procedure should be done. The operation of radical thyroidectomy as illustrated in Figure 70 is applicable to this situation. The incision is illustrated in Figure 69, No. 6, and the operation is essentially a radical neck dissection combined with total hemithyroidectomy and removal of the strap muscles on one side. In addi-

tion to this the thyroid isthmus should be removed, and a subtotal thyroidectomy should be done on the opposite side. This last is done as an additional safeguard against contralateral extension of the disease. The neck dissection part of a radical thyroidectomy does not usually include the submaxillary triangle. The recurrent laryngeal nerve will often be involved in, or destroyed by tumor, but sacrifice of the intact nerve on one side should be done without hesitation when necessary.

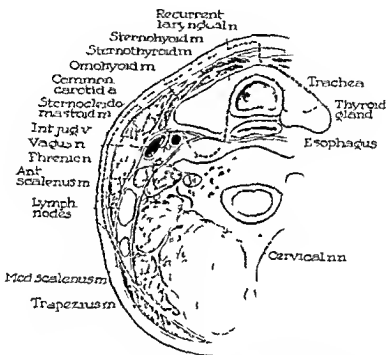


Fig. 71. Cross section of the neck at the level of the thyroid isthmus showing the block of tissue removed in the operation of radical thyroidectomy. The tissue removed is outlined by the heavy black line.

Contrary to the practice in neck dissection for epidermoid carcinoma, radical thyroidectomy should usually be followed by x radiation to the thyroid bed and neck. The most common types of thyroid carcinoma are partially controllable by radiation, and the usual slow growth and long duration of these tumors allow a worthwhile increment of symptom-free life by such treatment in the incurable cases. Ideally, whenever a radical thyroidectomy is contemplated, gold radon seeds should be available for implantation into nonresectable tumors. The anatomical location of the thyroid gland frequently creates the situation in which the metastases of a carcinoma of this organ can be easily removed but the primary lesion cannot because of direct ex

tension into the trachea, thyroid cartilage, esophagus or common carotid artery. The bulk of the primary lesion should be excised in such a situation, and the remaining tumor implanted with the gold radon seeds. The seeds should be inserted into the tumor at intervals of approximately 0.5 cm in three dimensions, and should be of 1.0 to 1.5 millicuries in strength. Such interstitial gamma radiation will frequently destroy visible residual cancer.

DISABILITY FOLLOWING NECK DISSECTION

Disturbances in function following neck dissection in the adult are surprisingly small. The most common residual defect is shoulder drop due to transection of the eleventh cranial nerve, a frequent necessity. Damage to the recurrent laryngeal nerve in patients with thyroid cancer or following accidental damage to the vagus nerve has well known sequelae. Injury of the hypoglossal, lingual or phrenic nerves are surgical accidents and should be avoided. Removal of the sternomastoid, omohyoid and ribbon muscles apparently have little functional effect. As a rule, most patients have few or no complaints attributable to the operative procedure itself.

CASE REPORTS

The clinical situations in which neck dissections are indicated are almost as standardized as the indications for radical mastectomy. It would seem superfluous to recount case histories of routine clinical problems involving neck dissection for metastases from carcinoma of the lip, tongue or other head and neck structures. However, two phases of the problem seem worthy of emphasis. These are, first, the futility of inadequate surgery, and second, the problem of a swelling in the neck as a patient's presenting complaint.

CASE 1—The patient is a 72 year old white male admitted to the Presbyterian Hospital on March 22, 1944. Five years previously he had first noticed a swelling in the right upper neck in the region of the lower pole of the parotid gland. X-ray treatment was administered without result. In June, 1940 surgical excision of the mass was done and the surgeon noted that the tumor tissue was gray friable and appeared to be malignant. The microscopic diagnosis was atypical adenoma of a salivary gland. The tumor recurred and in September 1941 was again excised. At this operation hemorrhage was so profuse that ligation of the external carotid artery was necessitated. Further x-ray radiation was given following this procedure. The tumor recurred accompanied by enlargement of cervical nodes, and in March 1943 a third excision was done. This specimen was reported as adenocarcinoma. The cancer recurred rapidly following this operation and in spite of further x-radiation involved multiple nodes in the right neck and extended to the skin in the midsternomastoid region. Retroclavicular nodes were enlarged. The patient was then subjected on March 23, 1944 to complete radical neck dissection with wide removal of the site of skin involvement and excision of the area of previous surgical attack. When last examined on July 31, 1945, the patient had no evidence of recurrent disease.

Eventual cure of this patient is doubtful because of the advanced stage of his disease when radical surgical attack was finally done. After the complete neck dissection the patient has experienced his longest interval of freedom from evidence of tumor since the onset of the lesion. It seems reasonable to believe that radical surgery earlier in the course of the disease would have given a better chance of complete eradication of the cancer.

CASE II—The patient is a 38 year old white female who was first examined at the Research Hospital on May 9 1945. Eighteen months previously she had developed a small lump in the right midneck. She consulted her physician who told her to forget about it and she maintained this counsel until she consulted another doctor ten months later. At this time there were two masses in the neck one of which was removed for biopsy. This tissue was reported as carcinoma and without examination the patient was given x ray therapy to the right midneck. The neck enlargement persisted even under treatment and eight months later was larger. On examination in the tumor clinic at the Research Hospital an indurated scar in the right midcervical region and a movable node below the angle of the mandible measuring 2.5 cm. were found. Inspection of the nose epipharynx oral cavity and hypopharynx revealed no evidence of a primary malignant neoplasm. Both vocal cords moved freely. The right thyroid lobe was questionably enlarged and in its central portion there was a suggestive small area of induration. Physical examination otherwise was entirely normal. A tentative diagnosis of early carcinoma of the thyroid with cervical node metastasis was made the alternative of lateral aberrant thyroid disease being considered. Either diagnosis required exploration of the neck and the thyroid gland. This was done on May 31 1945 and the diagnosis of early carcinoma of the thyroid was established by frozen section. Accordingly a radical thyroidectomy was performed.

This case illustrates two general fallacies in regard to neck tumors. The first physician who examined the patient did not regard the situation as even potentially serious. This is an error because today most of the persistent swellings in the neck in the adult exclusive of goiter are malignant.

The second physician established the diagnosis but he then treated the neck swelling as a primary lesion without search for the real primary. This was an error because malignant epithelial tumor in lymph nodes is necessarily metastatic, and it is futile to treat secondary deposits without measures to control the primary focus.

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DIAGNOSIS AND TREATMENT OF CARCINOMA OF THE FEMALE BREAST

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RECOGNITION of early or relatively early carcinoma of the female breast by the well trained surgeon is for the most part not difficult on the basis of clinical and gross pathological findings. When a woman in the so called cancer age accidentally discovers a painless lump in her breast which is resistant to palpation and fixed in the breast tissue with dimpling of the overlying skin the diagnosis of carcinoma is self evident. The ability to recognize an early carcinoma before all the classical signs are present is the goal of every well trained surgeon. The late Arthur Dean Bevan frequently expressed the opinion that 95 per cent of the malignant growths of the breast should be recognized as such by the surgeon at the time of operation on the gross pathological findings alone. In only 5 per cent of the malignant tumors should it be necessary to enlist the aid of microscopic sections and the pathologist. In my opinion the operating surgeon should possess the necessary pathological training to make a correct diagnosis of the microscopic sections.

AIDS IN THE DIAGNOSIS OF CANCER OF THE BREAST

For the benefit of the surgeon all hospitals should provide adequate laboratory facilities under the direction of competent pathologists to supply accurate diagnoses. Every breast tumor should be submitted as a matter of routine to a thorough microscopic study by a reliable pathologist. A benign lesion cannot be distinguished from a malignant lesion of the breast by palpation alone. Even the best surgeons occasionally are jolted by a pathologist's report of malignancy when they had assumed from the gross appearance that the tumor was wholly benign. Unless the patient consents to a surgical excision for the purpose of biopsy, the responsibility for her care should be declined. Biopsy service is essential for the protection of both surgeon and patient, and it insures prompt and adequate surgery.

In addition to the biopsy service, there are certain clinical signs other than the classical ones that I consider very significant. At the present time they are not sufficiently emphasized as definite clinical aids in diagnosis.

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One characteristic of breast cancer is the absence of pain. Haagensen and Stout¹ furnish striking statistical evidence of this fact. A clinical review of 1040 unselected patients with breast cancer shows that only 1.6 per cent of the patients came to the physician because of pain. Many patients already have axillary node metastases when they come to the physician for the first time. If pain occurred simultaneously with the onset of cancer, it would bring many patients to the physician early in the course of the disease.

Another clinical aid in the diagnosis of breast cancer not sufficiently emphasized is the constancy with which cancer occurs as a solitary tumor nodule in the breast. In a study of some 500 surgical specimens of breast cancer, I found that only 3 per cent of the patients had more



Fig. 72.—Carcinoma occupying central portion with cyst formation.

than one nodule. Therefore, when two or more nodules occur in the same breast, malignancy probably is not present.

Aspiration, transillumination and radiography often are used in the diagnosis of breast lesions, but their value is limited. Aspiration may be used to determine whether the lesion is solid or cystic, and if it is cystic, to determine the microscopic character of the cystic fluid. Transillumination frequently is used for the same purpose. However, in neither instance does the presence of aspirated fluid or the transmission of light prove that the lesion is benign, for carcinomas as well as breast tissue may become cystic (Fig. 72). Therefore, this procedure should not be considered as an absolute diagnostic aid. Radiography may be useful in the special investigations of breast lesions but it is not practical for their routine differential diagnosis.

Seabold² has developed a complete routine for radiography, judi-

examinations, but rather to assist the examiner and the clinician in determining his approach to treatment."

Clinical and physical signs, supplemented by biopsy, constitute the best method of determining the diagnosis of breast lesions.

Problems in Early Diagnosis—When a physician does a hasty routine physical examination, he is very apt to overlook a tumor of the breast. The importance of a careful breast examination in routine physical checkups is presented by Hagensen and Stout.¹ They reviewed the cases of breast cancer in the Presbyterian Hospital, New York, over a twenty year period and found that 66 per cent of the cancers of the breast were discovered by routine physical examination.



Fig. 73—Illustrating the degree of adenopapillomatous hyperplasia in fibrocystic disease causing difficulty in diagnosis.

These examinations thus provide an opportunity for early diagnosis and proper treatment and should not be neglected.

Another difficulty is encountered in that group of breast tumors whose gross and microscopic pathology is indefinite and inconclusive. These tumors generally are called borderline or precancerous lesions. They occur almost exclusively in the proliferative and hyperplastic form of fibrocystic disease. Cheatle and Cutler³ are among the chief exponents of this view. This form of fibrocystic disease may be a benign adenopapillomatous growth or a precancerous lesion. In my experience, both as a pathologist and as a surgeon, the character of a small minority of the adenopapillomatous lesions in fibrocystic disease, whether nonmalignant or malignant (Fig. 73), cannot be conclusively

determined. In these circumstances radical surgery is undoubtedly indicated.

Another difficulty usually not mentioned in connection with the diagnosis of cancer of the breast is the occurrence of cancer in accessory breast tissue. Accessory breast tissue is a cordlike structure radiating outward and upward from the mammary gland periphery to rest on the front of the anterior axillary fold, or it may occur as single or multiple isolated nodules in the axilla proper. When malignancy occurs in the nodules a differential diagnosis cannot be made correctly without biopsy. However, a careful inquiry may reveal the fact that these nodules have been present for years and that they have consistently increased and decreased in size coincident with the pre and postmenstrual phases of the menstrual cycle. This clinical fact will furnish almost positive proof of the presence of accessory breast tissue.

The Significance of the Axillary Gland in Breast Cancer—The correct diagnosis of breast carcinoma is complicated by the presence of atypical manifestations of the disease. These atypical signs occur in patients who develop axillary node involvement before any positive clinical evidence can be detected of the primary tumor in the breast. The following case illustrates this type.

A married woman aged 38 years entered the hospital April 30, 1938 for menorrhagia from fibroids for which a vaginal hysterectomy was performed. Eight months before she had noticed a lump in her left axilla which was freely movable and was considered by her physician to be a simple adenopathy. On January 5, 1939 she was referred to me for biopsy of the axillary node. Careful palpation of the breast at this time revealed no convincing evidence of any tumor mass or masses. Biopsy of the axillary node revealed adenocarcinoma. On suspicion only radical mastectomy was advised and performed. The pathologist's report of the gross specimen mentions stellate like strands of tissue in the outer upper and outer lower quadrants studded with yellow pin point nodules. Both the breast and axillary nodes on microscopic section contained adenocarcinoma. She has had repeated irradiation treatments.

Four years after the radical mastectomy she developed local axillary recurrences which have been held in check with irradiation therapy. As a result extensive fibrosis of the shoulder and upper arm muscles has developed permitting only limited motion and causing extensive swelling of the entire left arm. She has developed no clinical signs of either visceral or bony metastases.

It is not known how long this breast cancer existed before axillary metastases developed, but the axillary nodes were known to have been present for almost two years although there was no palpable evidence of breast cancer.

Another atypical manifestation of breast cancer occurs when a patient with a radical mastectomy of one breast develops metastases in the opposite axilla with no clinical or physical signs of cancer in the corresponding breast. Recently a patient with a history like this was referred to me. The axillary mass in the opposite axilla was inoperable but no tumor mass could be palpated in the corresponding breast.

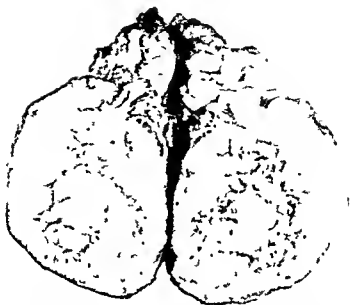


Fig 74—Resected breast specimen completely occupied by cancer. Axillary nodes normal.



Fig 75—Direct invasion of pectoralis major muscle by cancer cells in specimen of Figure 74

The metastases presumably had come from the side of the original radical mastectomy, for chest x-rays were negative

Cancer of the breast may occur in young women. The term "cancer age" should be discarded because no age group is immune to cancer. The fact that a patient is young is not proof of benignancy as has so often been supposed. De Cholnoky⁴ collected and studied the records of seventy-five women with mammary cancer under 30 years of age. He states that 2 per cent of all breast cancer occurred in women under this age. He regards the prognosis as no worse for the younger than for the older women.

Another misleading condition is the presence of a resistant mass in the entire breast with no palpable axillary nodes. The mass is not necessarily benign even though there is an absence of palpable axillary nodes. There is no relationship between the size of the primary tumor and its metastases to the axillary nodes. This fact is well illustrated by the following case (Figs 74 and 75).

A married woman, aged 48, was admitted to the hospital on March 12, 1931 because of a firm resistant mass occupying the entire right breast. No axillary metastases could be demonstrated by gross and microscopic studies. The cancer had invaded the underlying pectoralis muscle. Four months later she returned with multiple skin metastases of each loin, and two months later death resulted from cerebral metastases.

This case illustrates that metastases may occur through the blood stream rather than the lymph stream when the primary cancer is far advanced. There was no demonstrable axillary node involvement.

To determine clinically the absence or presence of axillary node involvement in breast cancer is not easy. Even careful and thorough palpation may fail, as it has on occasion in my own experience. Some very interesting observations were made in this connection by Hoopes and McGraw.⁵ In a series of 145 cases of operable breast cancer and clinically palpable axillary nodes, they found that thirty-four patients had no demonstrable metastases. However, in a series of ninety-seven patients with operable breast cancer and no clinically palpable axillary nodes, these same authors found that twenty-eight had demonstrable metastases. They conclude that clinical palpation for nodes is inadvisable because of the inaccuracy of the diagnosis and the danger of spreading the malignant cells.

The true incidence of axillary gland metastases finally depends upon the gross and microscopic pathological studies of the nodes in the laboratory. In a series of 254 patients with breast cancer, White⁶ found that 137 had axillary node involvement at the time of surgery. In a series of 132 similar patients, Rodman⁷ found that 70 had axillary node involvement, and in a series of 466 patients with breast cancer, I found that 209 had axillary node involvement. Therefore, half of the patients with breast cancer already have axillary node involvement, at the time of surgery. It is for us to devise a way to provide surgical treatment for every patient with breast cancer before the axillary nodes become involved.

The high percentage of axillary node involvement at the time of surgery can be lowered if the patient receives a careful examination of the breasts in routine physical checkups. Patients with known lumps in their breasts should consult a physician without delay and the physician must investigate every breast lump by biopsy. Since the early stage of cancer is painless every effort must be made to discover its presence.

TREATMENT OF OPERABLE BREAST CANCER

The treatment of cancer of the breast is much the same as the treatment of any other disease. There are two phases of a disease: the primary disease itself and the disease with its complications. This means that there is cancer without metastases and cancer with metastases. The treatment of the former is relatively simple, while treatment of the latter is complex, sustained, expensive, and frequently futile. Unfortunately, cancer without metastases often is as fatal as cancer with metastases.

In the actual treatment of breast cancer as a primary disease the surgeon first must decide whether the lesion is operable or inoperable. Surgeons generally agree that primary carcinoma of the breast is operable as long as the cancer has not spread beyond the axillary group of lymph nodes and that the greatest single weapon in the treatment of breast cancer is radical surgery meticulously executed. Surgery should be supplemented with adequate and intelligent postoperative irradiation. There is some controversy as to the extent of the surgery. The radical mastectomy as devised by Halsted⁸ is used extensively. However, frequent skin grafting is necessary to cover the denuded surface. Using Halsted's method, Rodman⁷ devised a modified skin incision that makes skin grafting unnecessary and still permits the resection of an equal or even greater area of skin.

The radical method of Halsted has seemed too extreme to some surgeons. The disfigurement is appreciable when both pectoralis muscles are ablated. To overcome this objection, Adair⁹ devised a modified radical procedure in which the pectoralis fascia is removed but not the pectoralis muscles. The muscles are retracted medially to allow an adequate axillary dissection. For a number of years I have used this method followed by adequate postoperative irradiation. A minimal degree of disfigurement results from this method and it does not affect the functional use of the corresponding shoulder and arm. When there is axillary node involvement I do not feel that the subsequent course of the disease will be materially altered by ablating the pectoralis muscles to allow resection of the subclavicular nodes. The reason for this, according to Callender,¹⁰ is that besides the axillary and clavicular lymph channels there are three other groups of lymph channels that drain the breast and likewise furnish avenues of spread. Surgery, however radical, cannot resect the nodes that receive the c

channels. Therefore, when the axillary group has been eliminated, only one of the four avenues of spread has been blocked. With local muscle and axillary node invasion I am convinced that the radical method of



Fig 76—Fungating bleeding mushroom like ductal carcinoma of the end of the nipple with axillary node metastases

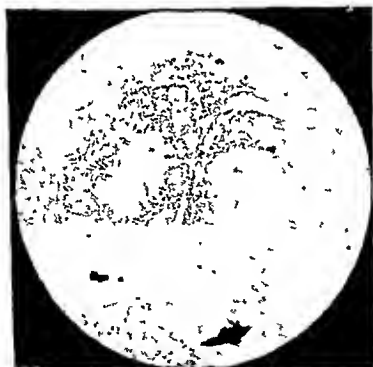


Fig 77—Microscopic sections of Figure 76 showing ductal cancer

Halsted with postoperative irradiation therapy provides the most effective means today of combating the disease and preventing recurrences. The following case history substantiates this view in part and in addition it presents an interesting malignancy (Figs 76 and 77)

A married woman aged 52, was admitted to the hospital on January 30, 1978 because of a fungoid, bleeding, bulbous and ulcerating tumor at the tip of the nipple. It had been present for two years but had not bled until three months previously. On two occasions she went into collapse from excessive hemorrhage. A radical mastectomy was done. Many of the axillary nodes were involved. The primary tumor was a ductal adenocarcinoma. She received postoperative irradiation therapy. On August 20, 1945, no evidence could be found of recurrence. She has remained clinically well for seventeen and one half years since surgery.

The use of preoperative irradiation has lost most of its popularity in recent years. Herrmann¹¹ reports that it was used for a six year period at the Memorial Hospital, New York. It has been discontinued because it resulted in more bleeding on operation, a delay in wound healing and no increase in the percentage of five-year survivals. I have never used preoperative irradiation except in an occasional inoperable case when surgery was used as a palliative measure only.

TREATMENT OF RECURRENT AND INOPERABLE CANCER OF THE BREAST

Patients with one or several of the following signs cannot be cured by operation: (1) edema of the corresponding arm, (2) fixation of the tumor to the chest wall, (3) fixation of the axillary nodes, (4) invasion of the supraclavicular lymph nodes, (5) local metastases to the skin, (6) distant metastases whether visceral or skeletal, (7) the inflammatory type of cancer, (8) open ulceration of the primary lesion in the breast. These criteria of inoperability are based on the survival rate.

There is, however, more controversy among surgeons when the criteria of inoperability are viewed from the standpoint of providing relief. We have no way of knowing whether these patients would live longer with early surgery or without surgery. All the symptoms of inoperability frequently develop regardless of early surgery. Early radical mastectomy has not increased the life expectancy of these patients.

In recent years we have adhered less strictly to the criteria of inoperability and have used surgery for relief, knowing that by doing so we may even detract from the life expectancy of the patient. In the first place, many surgeons now feel that the surgical removal of a primary malignant growth in the presence of metastases, regardless of the organ involved, tends to inhibit the growth of the metastatic foci. To what extent this can be proved scientifically is not known. However, when a patient is suffering from an open, malodorous and ulcerating cancer of the breast, she will benefit both physically and mentally from the removal of such an objectionable lesion by a modified radical or simple mastectomy. Replacing such a lesion by clean healthy skin, not too devitalized by irradiation, is a great service to that patient.

In the second place more than a pure scientific effort is essential for a patient with inoperable cancer. When scientific effort fails, surgery is justified. We feel that the removal of an inoperable breast is justified when it instills new hope for recovery and improves the morale of the patient. However, in a recent report, Haagensen and Stout¹² state that on the basis of statistical data "patients with inoperable carcinoma of the breast live longer when not operated upon than if operated upon." But in my opinion it is more humane to provide a hopeful life for one month with the art of surgery than to provide a hopeless life for six months with the science of surgery.

In the treatment of local recurrences we recommend the skin incision devised by Rodman⁷ combined with either the radical or modified radical mastectomy as a preventive measure. In a series of 132 patients with breast cancer he reports a low local recurrence rate of 2.2 per cent. Using the Handley method, White⁸ reported a recurrence rate of 22.6 per cent in 238 patients with radical mastectomies. Using the Halsted method, Lewis and Rienhoff¹³ reported a local recurrence rate of 19.2 per cent in 950 patients.

In the active treatment of local recurrences we employ local excision followed by vigorous irradiation. In the event of axillary or clavicular lymph node fixation, irradiation therapy alone is employed. In some cases the results have been gratifying, and the life expectancy of the patients has increased. The following case illustrates the value of using irradiation alone.

A married woman aged 29 entered the hospital on July 10, 1940, with a diagnosis of adenocarcinoma of the left breast made from a biopsy section in another hospital. A modified radical mastectomy was done, and one small axillary node contained a metastatic tumor. She received the routine postoperative irradiation therapy. Four years later she returned with a definite mass in the left supraclavicular node. This was treated with irradiation. Now there is no clinical evidence of supraclavicular node involvement or metastases.

One of the most constant postoperative complications in radical mastectomy is the swelling of the corresponding arm. There are several causes of this condition. In my experience mild swelling of the arm invariably occurs after a radical mastectomy with excision of the axillary lymph nodes. This is lymphedema which results from a lymphatic block. Another significant cause of this condition is irradiation fibrosis of all the structures about the shoulder, including the subcutaneous tissues, muscles, ligaments and joint capsule. Local recurrences in the axilla are usually associated with this irradiation fibrosis. Infections following radical mastectomy and trauma incident to surgery constitute additional factors. The treatment is mainly local, using such measures as hydrotherapy, massage and elevation of the arm. The Kondoleon operation has been uniformly disappointing. Holman¹⁴ and his associates report that primary wound healing, good axillary

drainage minimum operative trauma, avoidance of infection and roentgen ray dermatitis constitute important preventative measures

Our greatest problem is the treatment of distant metastases. The interesting feature of distant metastases is that some mammary cancers select viscera, such as the lungs, liver and brain, while others of the same type select bone. Only in a small minority of instances are the metastases both visceral and skeletal. In an exhaustive study of 90 patients with metastatic carcinoma secondary to breast cancer, Palleta and Lehman¹⁰ found that 48 had clinical signs of bone metastases, 35 visceral metastases, and 7 both bone and visceral metastases.

Irradiation therapy is valuable only in certain patients with skeletal involvement. The lesion is often destroyed and replaced by newly generated bone. The palliative effects may last for several years. In so far as visceral metastases are concerned, some good is obtained from pulmonary and cerebral irradiation but none from liver irradiation.

THE VALUE OF OOPHORECTOMY IN BREAST CANCER THERAPY

Because of the limitations of surgery and irradiation in the treatment of metastases in breast cancer, numerous approaches have been devised from the sex hormone angle.

Sir Astley Cooper¹⁶ was the first to suggest that the ovaries might have some influence on mammary cancer. Beatson¹⁷ was the first to introduce the concept of oophorectomy in women with breast cancer who are still in the premenopausal age. In support of his position he presented the account of a woman, aged 33 years who felt a hard lump in one breast while nursing her first child three years previously. A radical mastectomy was performed but local recurrences developed within a year. A bilateral oophorectomy was performed, and at the end of eight months all traces of local recurrences had disappeared. A few years later Schinzinger¹⁸ reported similar results in inoperable breast cancer following bilateral oophorectomy and he advised its use.

Other interesting accounts of this type of therapy have appeared in increasing numbers in recent years. From the Memorial Hospital, New York, Herrmann¹¹ made a report of 340 patients with metastatic or inoperable breast cancer. All were castrated, 307 by irradiation and thirty three by surgery. In only 15 per cent of the former and 13 per cent of the latter was there some improvement, such as increased appetite, gain in weight and diminished pain. Since castration by the two methods employed yielded similar results, he reports that castration now is done exclusively by irradiation because it is much less expensive and hazardous than surgery. Horsley¹⁹ on the other hand employed surgery and is so favorably impressed by the benefits of oophorectomy in the premenopausal woman with breast cancer that he refuses to perform a radical mastectomy unless the patient submits to a bilateral oophorectomy at the same time. He reports a series of

25 patients with breast cancer treated in this way, and only two thus far have developed recurrences. All his patients were operated upon between 1937 and 1943, so that no final conclusions can be drawn.

Thus far I have not felt that the results obtained from routine sterilization by bilateral oophorectomy wholly justify this rather major surgical procedure. Since the elimination of various functions in these patients appears to be palliative and not curative, irradiation is a much more simple, economical, and less hazardous method of sterilization. It should be the method of choice if sterilization is used at all.

VALUE OF ESTROGENS AND ANDROGENS

Another hormonal approach is the use of estrogens and androgens. Our knowledge of sex hormones at the present time is fragmentary and frequently contradictory. Farrow²⁰ conducted some studies on the use of both estrogens and androgens in skeletal metastases. He concluded that our knowledge is still incomplete, that the withdrawal of either hormone in certain cases might inhibit the growth, that an excess of either hormone might stimulate the rate of growth and that whatever effects were obtained were probably inconstant and temporary. On the other hand, Prudente²¹ of Brazil presents some very interesting and encouraging findings in a series of 127 patients with operable cancer of the breast. He used testosterone propionate postoperatively in sixty-three patients and the remaining sixty-four were used as controls, with surgery only. He concluded that the survivals of three, four and five years were 100 per cent better with the use of testosterone than without its use.

I have not employed any of the sex hormones thus far in the treatment of breast cancer or its metastatic lesions, nor used ovarian castration. One should not become too enthusiastic over measures that may tend to increase the survival rate only and possess little or no curative value. If their use serves only as a means of prolonging the existence of a dying and suffering patient, and add grief and hardship to those who administer to that patient, then what has seemed like a gain may be equally considered a loss.

Whenever attempts are made to evaluate the benefits of castration or sex hormones, we are apt to lose sight of the significant fact that essentially all or nearly all of the patients have already had the benefit of a meticulous radical mastectomy. It can be readily appreciated how credit may be assigned to the use of hormones or castration or both instead of radical surgery combined with irradiation therapy. This latter method is the treatment of choice. However, since we are all deeply concerned about finding some successful method of combating and ultimately curing mammary cancer, we shall always continue to give help and encouragement to every honest effort from whatever angle.

CONCLUSIONS

1 In the diagnosis and treatment of breast cancer, it is of supreme importance that the surgeon be thoroughly trained in surgical pathology as well as in clinical surgery

2 The indispensability of an adequately trained pathologist and an adequately equipped laboratory for biopsical studies has been emphasized

3 Every member of the medical profession should adopt the rule that every breast 'lump' should uncompromisingly be submitted to biopsy

4 The diagnostic procedures of aspiration transillumination and radiography should be looked upon as having limited value as accurate diagnostic procedure, and they are not practical for routine breast examinations

5 The value of early recognition and early surgery of cancer has been duly stressed

6 The employment of methods of therapy whose accomplishment are at best palliative and not curative such as castration and sex hormone therapy, should be kept in their rightful place

7 The greatest weapon in combating cancer of the breast is meticulous radical or modified radical surgery combined with irradiation therapy from the standpoint of prophylaxis recurrence and inoperability

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SURGERY OF THE MEDIASTINUM

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SURGERY of the mediastinum now includes the operative treatment of a large variety of disorders. Between the two pleural cavities there are many important organs and structures, such as the heart and great vessels, the esophagus, trachea, thymus, nerves and lymphatic tissue. These structures may be involved by congenital lesions, infections, tumors or cysts or by traumatic wounds.

During the past three decades management of cardiorespiratory function during a surgical pneumothorax has become better understood, so that exposure of the mediastinum for examination or for various operative procedures now entails no more risk than exploration of the abdomen. Formerly, operative therapy consisted chiefly of the drainage of cysts, a procedure which was accompanied by considerable risk. Now the scope of surgery in this field is extensive, the more common procedures including removal of benign tumors and cysts, drainage of acute infections, release of constrictive pericarditis, suture of wounds of the heart, closure of patent ductus arteriosus and resection of carcinoma of the esophagus. The following cases illustrate some of the more common operative procedures.

CASE I DERMOID CYST OF THE MEDIASTINUM

A 45 year old white woman came to the clinic complaining of chest trouble which had been demonstrated by a routine x ray of the chest one month previously when she applied for work at an ordnance plant. Prior to that time she had had no symptoms and no reason to believe that there was anything wrong with her chest.

to admission but no treatment had been required. The remainder of the history was entirely irrelevant.

Physical examination revealed a well developed and well nourished woman who appeared to be in normal health. Her blood pressure was 100/75 and her pulse rate was 88 per minute. The positive physical findings were limited entirely to the chest. On examination the right side was noticed to move less than the left during deep inspiration. The intercostal spaces were deeper and wider making the ribs seem somewhat prominent. Vocal fremitus was diminished markedly in the anterior aspect of this side. On percussion there was dullness to flatness over the anterolateral portion of the right chest in the lower two thirds. The remainder of the chest was normal. The breath sounds were markedly diminished or absent over the above region and normal elsewhere. The cardiac dullness and heart tones were within normal limits.

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The laboratory findings demonstrated a normal blood count and hemoglobin value and a normal urine. An x-ray examination of the chest showed a huge rounded soft tissue mass measuring approximately 14 cm in diameter in the right lower lung field anteriorly (Fig 78). There was no clear evidence of calcification within this shadow which appeared to be projecting into the right chest from the anterior mediastinum. Fluoroscopy revealed no expansile pulsations. The right leaf of the diaphragm moved normally. The diagnosis made on the basis of x-ray and fluoroscopic findings and the lack of a history of symptoms was *dermoid cyst of the mediastinum*.

The patient was advised to enter the hospital for operative removal. Since the blood picture including a plasma protein of 6.5 gm per cent was within normal limits there was little preparation needed for operation.



Fig 78 (Case I)—X-rays of the chest prior to operation showing a large circumscribed opacity extending to the right from the anterior mediastinum in the lower two thirds of the right chest. No calcification is seen and there has been no destruction of bony structures.

Anesthesia Supportive Therapy—The operation was performed under ethylene plus oxygen plus ether given through a snugly fitting face piece under mild positive pressure (6 to 8 mm of mercury). The anesthesia was preceded by morphine 0.01 gm (H) and calcium nembutal 0.27 gm in 55 cc of water per rectum both being given nine and one half hours before operation. An intravenous saline infusion was begun and 700 cc of blood were given during the operation.

Operative Technique—Exploratory Thoracotomy and Excision of Dermoid Cyst of Mediastinum—A semilunar incision was made beginning over the third right intercostal space just below the third costal cartilage, extending downward under the right breast and continuing upward and outward laterally into the posterior part of the right axilla (Fig 79, A). The muscles were divided in the line of this incision,

which for the most part was over the course of the right sixth interspace. After exposing the right fourth, fifth and sixth costal cartilages these were divided just lateral to the edge of the sternum, the internal mammary vessels being ligated by suture just beneath the third and just above the sixth cartilages. The pleural space was opened through the sixth interspace and along the line of division of the costal cartilages next to the sternum. The edges of the wound were separated and exposure was obtained by a self retaining rib spreader (Fig 79, B and C). On entering the pleural cavity, a large cystic mass was found

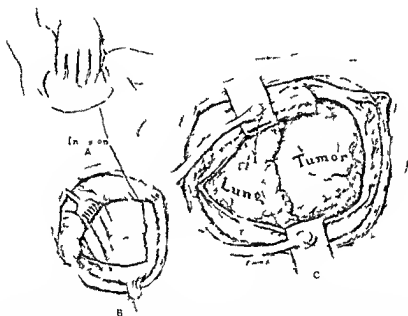


Fig 79 (Case I) —Drawing showing skin incision (A) extending from the 4th costal cartilage downward beneath the right breast and into the posterior axillary line. After reflecting the muscles of the chest wall the incision is along the course of the 6th intercostal space and the divided 4th, 5th and 6th costal cartilages. With the rib spreader in place the tumor is seen to occupy a large part of the lower pleural cavity anteriorly the lung being pushed laterally and posteriorly.

occupying the lower two thirds of the right pleural cavity anteriorly which was displacing and compressing the right lung posteriorly and upward. The cystic mass was covered by mediastinal pleura. This was incised, and with relatively little difficulty the tumor mass could be dissected free from the chest wall, pericardium and diaphragm. Two or three blood vessels were clamped and ligated with chromic No. 00 catgut.

After removing the cyst, the right middle lung lobe, which had been almost entirely atelectatic as a result of compression, again became aerated.

A No. 26 Pezzar catheter was brought out through a stab wound in the seventh intercostal space laterally for continuous suction drainage of the pleural cavity and re-expansion of the right lung. The ribs were then reapproximated with two pericostal sutures of double strand of chromic No. 1 catgut. The reginn of division of costal cartilages was reunited by interrupted sutures of chromic No. 00 catgut. The intracostal structures were approximated in the lateral one-half of the wound with a running stitch of chromic No. 00 catgut suture. The remainder of the muscles and deep fascia of the chest wall were reapproximated with interrupted sutures of the same material. Plain No 00 catgut sutures were used for the subcutaneous tissue, and silk was



Fig 80 (Case I).—Photograph of bisected surgical specimen showing its cystic nature. Note the thin wall and smooth lining of the cyst and the presence of hair.

used for the skin. Following closure of the chest wall, complete re-expansion of the right lung was obtained by aspirating the residual air from the pleural cavity. The patient's blood pressure, pulse and respiration remained within normal limits throughout the operation.

Surgical Pathology.—The specimen consisted of a large thin-walled cyst measuring approximately 14 cm. in diameter and weighing 950 gm. (Fig. 80). The wall was transparent in some places and smooth except where it had been dissected free from the mediastinum. On section it was found to contain a yellowish fluid, cheesy material and some enmeshed hair. In one region a septum was present containing cartilaginous-like material. Microscopic sections revealed a lining of stratified squamous epithelium containing hair follicles and sebaceous

glands. The wall of fibrous tissue surrounding this contained some areas of round cell infiltration. The final diagnosis was *dermoid cyst*.

Postoperative Course—The patient had a very uneventful convalescence, the temperature never going above 100° F. There were no respiratory difficulties or other complications. She was discharged from the hospital two and one-half weeks after operation. The last time she was seen was about eleven months after the operation, at which time she was entirely asymptomatic. An x-ray of the chest appeared normal. Most of the scar of operation was hidden beneath the breast.

Comment—Mediastinal dermoids are usually located in the anterior mediastinum. They produce no symptoms until they become quite large and cause pressure on adjacent structures such as the lung, chest wall or great vessels. The differential diagnosis is usually not difficult since they are almost always located in the lower anterior mediastinum. Operative removal is indicated since they tend to undergo malignant degeneration. The prognosis is good.

CASE II. NEUROGENIC TUMOR OF THE MEDIASTINUM

An 18 year old white man came to the clinic because of a lesion found in the upper part of the chest on routine x-ray examination. He stated that he had not paid any attention to any particular symptoms he had been having until he had a knowledge that this abnormality was present. On retrospect he remembered that he had had some pain in the region of the right shoulder for the preceding several months. This pain had been dull in character but was not constant. It was not severe enough to cause him to seek medical attention. It was produced chiefly by bending over, by lying on the right side or on raising the arms forward. The remainder of the history was entirely irrelevant.

Physical examination revealed a small thin individual relatively normally developed. His blood pressure was 118/92 and the pulse rate 60 per minute. The remainder of the examination was entirely normal.

The laboratory tests showed a normal blood and urine. Fluoroscopy revealed an opacity approximately 2 to 2.5 inches in diameter located in the upper part of the right chest adjacent to the mediastinum. On rotating the patient this opacity was found to lie in the plane of the vertebral bodies. There was no evidence of pulsation. X-rays of the chest confirmed the fluoroscopic findings (Fig. 81). The diagnosis based on the history, the location of the tumor and the lack of pulsations was *neurogenic tumor of the mediastinum*. The patient was advised to have the tumor removed and was admitted to the hospital for operation. Since he was in good general condition very little preoperative preparation was needed.

Anesthesia—The anesthetic used was ethylene plus oxygen plus ether, delivered through a snug fitting face piece.

Operative Technique—A long curved incision was made over the right sixth rib and the muscles of the chest wall were divided in the line of the incision. The entire sixth rib was removed subperiosteally, and the pleural cavity was entered through this rib bed. No adhesions between the lung and chest wall were present. On retracting the lung anteriorly a tumor mass measuring approximately 3.5 by 5 cm. was seen arising at the junction of the third, fourth and fifth ribs with the

spinal column. The tumor was covered by the mediastinal pleura, was very hard and showed no evidence of fluctuation. After incising the mediastinal pleura over the tumor, it was mobilized by a combination of blunt and sharp dissection. There were fairly firm fibrous bands connecting the tumor posteriorly at the junction of the rib and vertebra. This was thought to be the origin of the tumor from an intercostal nerve. There was very little bleeding encountered. After obtaining hemostasis, the pleura was again closed over the raw area.

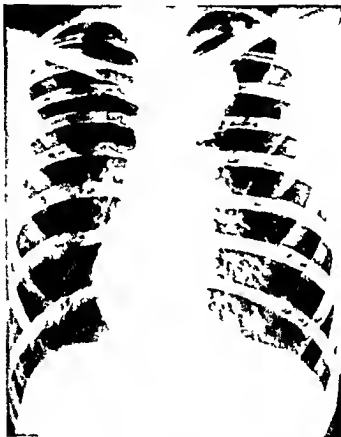


Fig. 81 (Case II) —X ray of chest showing circumscribed opacity extending to the right of the superior mediastinum in the region of the posterior end of the right fourth and fifth ribs.

A No. 26 Pezzar catheter was brought out through a stab wound in the ninth intercostal space in the posterior axillary line for continuous suction drainage of the pleural cavity. The chest wound was closed with two pericostal sutures of a double strand of chromic No. 1 catgut. The intercostal structures were united with a continuous suture of a double strand of chromic double No. 00 catgut. The deeper muscles and fascia of the chest wall were approximated with a combination of interrupted and continuous sutures of chromic double No. 00 catgut. Plain No. 00 catgut was used for the subcutaneous tissue and silk for the skin. The residual air in the pleural cavity was aspirated

through the drainage catheter with a pneumothorax apparatus following closure of the wound

The patient had a very quiet postoperative course, the temperature never being above 100.5 degrees. The drainage catheter was removed on the fourth postoperative day. The wound healed by primary intention and the patient was discharged from the hospital eleven days following operation.

Postoperative Course—The patient was seen on a number of occasions following operation and at no time presented any complaints. The pleural cavity remained free of fluid and the lung completely

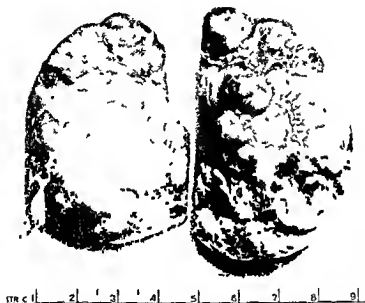


Fig 82 (Case II) Photograph of surgical specimen showing a somewhat nodular and circumscribed solid lesion measuring approximately 6 by 4 cm. Microscopic sections revealed a neurofibroma.

expanded. When last seen six months following operation, he was entirely free of symptoms and working full time.

Surgical Pathology—The specimen consisted of a 58 gm, well encapsulated tumor measuring 4 by 4 by 7 cm. It was pale pink and yellow in color with fine vessels going through the fine tissue capsule. The cut surface showed a translucent opalescent gray to yellowish material with white necrotic spots. The cut surface tended to bulge (Fig 82). Microscopic sections showed a poorly vascularized fibrous tissue stroma with areas of necrosis and round cell infiltration. There were little whorls or palisadings of cells with gray cytoplasm in some areas and the connective tissue lamina were regularly aerated. The final diagnosis was *neurofibroma of the mediastinum*.

Comment.—Mediastinal tumors of nervous tissue origin are usually located in the posterior mediastinum and produce no symptoms until they have undergone malignant degeneration or have caused pressure on adjacent structures. The diagnosis is usually not difficult. They are differentiated from cysts of the posterior mediastinum, intrathoracic goiter and aneurysm by the absence of symptoms and x-ray and fluoroscopic findings. Operative removal is indicated, and the prognosis is good if no malignant changes have developed.

CASE III CARCINOMA OF THE ESOPHAGUS

A 55 year old white man came to the clinic complaining of difficulty in swallowing food for the previous nine or ten months. During the latter two or three months of this period he had a pain in the epigastrium on swallowing solid

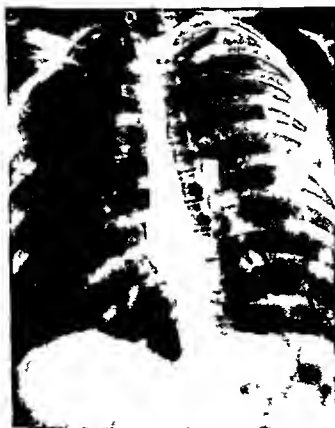


Fig 83 (Case III) —Preoperative x ray of chest following ingestion of barium showing an obstructing lesion of the lower one third of the esophagus. The tumor extended approximately $1\frac{1}{4}$ inches higher than the level suggested by the x ray

food and had a tendency to regurgitate food that had not passed into the stomach. During the entire period of ten months he had lost approximately 35 pounds in weight and a great deal of strength. The difficulty in swallowing at first had been only for solid food. However, in the latter part of this period he had difficulty in swallowing liquids as well. There had been no other complaint. On examination the patient was markedly emaciated and dehydrated, but did not appear acutely ill. The emaciation was so marked that loops of bowel could be identified be

neath the abdominal wall. His blood pressure was 128/74 mm of mercury. The rest of the examination was within normal limits.

Laboratory tests revealed a hemoglobin of 14.0 gm, white blood count of 11,000 and a normal urine. Fluoroscopic examination of the chest showed only bilateral emphysema. A barium study of the esophagus showed marked obstruction at the junction of the middle and lower one third. At this point a ragged mass could be seen. Lower down at the gastroesophageal junction the longitudinal folds were normal (Fig 83). The x-ray diagnosis was carcinoma of the esophagus.

During the next ten days the patient was prepared for operation by correction of the marked dehydration with saline and glucose administered intravenously.

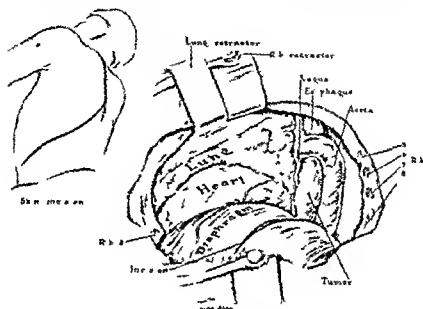


Fig 84 (Case III) —Drawing showing skin incision over the entire course of the 8th rib and extending upward over the posterior end of the 7th, 6th, 5th and 4th ribs. After resecting the entire 8th rib subperiosteally and a 1/2 inch segment of the 7th, 6th and 5th ribs posteriorly, the pleural cavity was entered along this line. With an automatic rib spreader in place and the lung retracted, excellent exposure is obtained.

Anesthesia Supportive Therapy—Preoperative medication of morphine 0.01 gm (H) and calcium nembutal 0.18 gm by rectum were given one and one half hours before surgery. The anesthesia consisted of ethylene plus oxygen plus ether administered through a snug fitting face piece. An intravenous saline infusion was started at the beginning of the operation.

Operative Technique—A long incision was made over the entire course of the eighth left rib and continued upward posteriorly over the seventh, sixth and fifth ribs. The muscles of the chest wall were divided in the line of this incision down to the bony thorax. The entire eighth rib and short segments (1 1/2 inches) of the seventh, sixth and fifth ribs

were removed subperiosteally. The fifth, sixth and seventh intercostal vessels were divided posteriorly between clamps and ligated. The pleura was then opened along this line posteriorly and throughout the bed of the eighth rib. No pleural adhesions were present (Fig. 84). The mediastinal pleura was incised over the course of the esophagus posterior to the hilum of the left lung to the arch of the aorta and the left pulmonary ligament was divided. The esophagus was then mobilized in this region care being exercised not to open the right pleural cavity. A tumor mass involving approximately 4 inches of the esophagus was found. It extended from just beneath the arch of the aorta downward and could be separated from the surrounding structures without much difficulty. The diaphragm was then opened from a point near its attachment to the chest wall at the anterior end of the incision inward to the esophageal hiatus the phrenic vessels being clamped and ligated in the line of the incision. Palpation of the liver and other structures in the upper part of the abdomen revealed no evidence of metastases. The spleen was removed to facilitate mobilization of the stomach and to aid in the anastomosis of the stomach with the esophagus after removal of the tumor. The stomach was then mobilized by dividing the vessels along the greater curvature of the stomach just outside of the main course of the gastroepiploic artery, care being taken to preserve the blood supply through this artery as much as possible. The left gastric vessels were then mobilized and divided near their origin between clamps. All vessels were ligated with chromic No. 00 catgut sutures. This allowed the stomach to be brought up into the chest cavity. The esophagus was crushed and ligated with linen near its junction with the stomach. A soft rubber clamp was then placed across the cardia and the esophagus was divided between the clamp and ligature care being taken to minimize soiling. A rubber glove was inverted over the lower end of the esophagus and secured by two braided silk ligatures.

The cardiac end of the stomach was closed by a double row of continuous linen sutures. Mobilization of the esophagus was continued to a point about 2 inches above the arch of the aorta. Sufficient space was made for the tumor to pass up beneath the arch and the esophagus was brought outside of this structure since it was impossible to make the anastomosis beneath the arch. The fundus of the stomach was then drawn upward and secured to the parietal pleura with interrupted sutures. The anastomosis between the esophagus above the level of the tumor and the fundus of the stomach was made by using two rows of interrupted linen sutures. The first row was placed medially before the tumor was removed. Prior to the division of the esophagus a right angled rubber shod soft clamp was placed across the esophagus and a similar soft rubber shod clamp was placed across the fundus of the stomach and the anastomosis was completed. Caution was taken during this procedure to minimize the amount of soiling of the surrounding

tissues. Additional interrupted sutures were placed to secure the stomach to the chest wall in order to relieve any pull that would create tension on the suture line between the esophagus and the stomach (Fig 85)

A No. 26 de Pezzar catheter was then brought out through a stab wound in the ninth intercostal space posterolaterally for continuous

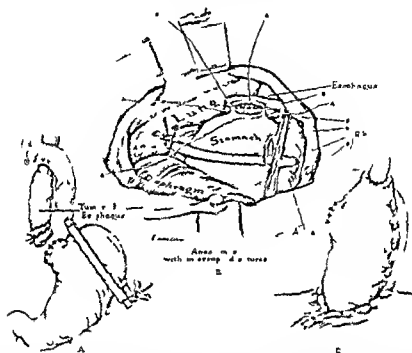


Fig 85 (Case III) —A The lower two thirds of the thoracic esophagus and the upper four fifths of the stomach have been mobilized and the esophagus divided at the cardiac end of the stomach B Rubber-shod clamps have been placed across the fundus of the stomach and the upper cut end of the esophagus in preparation for the anastomosis The posterior part of the outer row of interrupted sutures has been placed as indicated at A and the posterior portion of the inner row of interrupted sutures has also been placed as indicated at B C, The anastomosis between the upper cut end of the esophagus and fundus of the stomach has been completed at a level just above the arch of the aorta The diaphragm has been approximated about the stomach with interrupted sutures

suction drainage of the pleural cavity following closure of the chest wall The diaphragm was now closed about the stomach with interrupted and continuous chromic No. 00 catgut sutures Two and one half grams of sulfathiazole crystals were distributed about the region of the anastomosis Closure of the chest wall wound was made using two pericostal sutures of a double strand of chromic No. 1 catgut The intercostal structures were approximated with a continuous suture

of a double strand of chromic No. 00 catgut. In the region of the divided pleura posteriorly, closure was made with interrupted sutures. Closure of the muscles and deep fascia of the chest wall was made by a combination of interrupted and continuous chromic double No. 00 catgut sutures. Plain No. 00 sutures were used for the subcutaneous tissue, and silk for the skin. The residual air in the pleural cavity following closure of the chest was removed by aspiration through the drainage catheter with a pneumothorax apparatus.



Fig. 86 (Case III).—Postoperative x-ray following ingestion of barium and showing approximately four fifths of the stomach brought up into the pleural cavity for anastomosis with the upper esophagus following resection of the carcinoma. The anastomosis is shown just below the substernal notch.

The patient went through the operation without showing any evidence of shock, the blood pressure being 130/70 and the pulse rate 100 per minute at the end of the operation. He received 1200 cc. of citrated whole blood and 1500 cc. of saline intravenously during the course of the operation.

Postoperative Course.—Convalescence following operation was entirely uneventful, the temperature never reaching over 100.5° F. rectally. Water was taken by mouth beginning on the fifth day after operation, and a full liquid diet was taken by the end of nine days. The amount of fluid was limited to 60 cc. per hour at the onset and

was gradually increased to 120 cc per hour within the next three days. By the end of twelve days the patient was taking six soft feedings a day with fluids as he wished. The wound healed by primary intention, the de Pezzar catheter being removed the fourth day following operation. The patient gained rapidly in strength and was discharged from the hospital approximately three weeks following operation. He has continued to do well and was last seen eight months following operation at which time there was no evidence of recurrence of the tumor (Fig. 86).

Surgical Pathology—The specimen consisted of a section of the esophagus containing the tumor which measured approximately 3 cm in diameter and $4\frac{1}{2}$ inches in length. The tumor was very hard and on cut section was found to involve the entire circumference of the esophagus. The wall of the esophagus in the region of the tumor was greatly thickened. The tumor extended downward but did not involve the cardiac end of the stomach, a portion of which had been removed with the lower esophagus. One enlarged hard lymph node was attached to the esophagus and was invaded by a tumor. Microscopic section revealed the primary tumor to be a *squamous cell carcinoma*. The lymph node removed with the main tumor was also involved by the same type of a tumor.

Comment—Although not typical for carcinoma of the esophagus, dysphasia is more commonly caused by this tumor than by any other lesion. The diagnosis is usually not difficult to make when the possibility of esophageal neoplasm is kept in mind. A history of increasing difficulty in swallowing with x-ray evidence of obstruction in the esophagus should make one suspicious of this lesion. Differentiation from benign stricture or from cardiospasm can usually be made by esophagoscopy and x-ray examination.

During the past decade considerable progress has been made in the surgical management of carcinoma of the esophagus. When the diagnosis is made during its early course the prognosis after surgical resection is encouraging. Although operations for removal of these tumors has carried considerable risk in the past, at the present time the danger is not formidable and the operation offers the only chance for survival in this group of patients.

CLINIC ON PNEUMONECTOMY, STRESSING THE TECHNIC OF OPERATION

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ONLY within the last ten years has the technic of pneumonectomy been developed to the point where this operation can be performed successfully. The indication for this operation has been known for a long time. The cure for lung cancer is the radical removal of the lung, just as the cure for breast cancer is the radical removal of the breast. Up to the year 1934, however, death followed or accompanied every attempted lung resection. In that year I. A. Harts Grahm operated upon a physician who survived and resumed an active practice.

Undoubtedly the most important factors in bringing about this change from failure to success was the realization that the bronchial stump, in order to remain closed, had to be covered by some tissue other than bronchial tissue and that the tissues of the mediastinum were available to supply the fibrous tissue necessary. For years the bronchus had been treated like the bowel. The mucosa was inverted and the outer wall of the bronchus brought together the way we inverted the mucosa and submucosa of the bowel and brought together the serosa, but the bronchial stump would not heal. Some other tissue was necessary to cover the bronchial stump. Successful lobectomies could be performed on dogs because the pleura of the remaining lobes of the lung covered the bronchial stump and the desired closure was accomplished. Finally we realized that the bronchial stump would heal buried under a flap of pleura or directly in the mediastinum.

Many other things, however, have occurred to help change pneumonectomy from an unsuccessful to a successful operation. We have better anesthesia than formerly. Shock is combated by means of blood transfusions, intravenous fluids and the like. The widespread use of the oxygen tent has contributed a great deal. The recent use of penicillin has helped to reduce the incidence of postoperative empyema. Now the operation of pneumonectomy for cancer of the lung can be performed with the assurance that the patient will be placed in no greater jeopardy than he would be in any one of a number of major intra-abdominal operations.

The patient is a woman in her early forties. Eight months ago she caught a cold which according to her statement developed into pneumonia. At that time she had fever, cough, bloody expectoration and pains in the chest. She recovered in about two weeks and had no remaining symptoms except for a slight cough.

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Three months later she had a repetition of what was called pneumonia and two

main bronchus several centimeters from the carina. He was able to obtain a specimen which was diagnosed adenocarcinoma. He referred her to me.

When I saw her I discovered a well nourished, well developed woman who did not look sick. There was a slight impairment in the percussion note and a definite diminution of breath sounds with an occasional rale of the lower left lung field. Otherwise there were no physical findings of significance. Her blood count was normal, there being 4,000,000 red cells with a very slight drop in hemoglobin. The x-ray showed a mass in the left hilus with a shadow over the left lower lung field which is interpreted as a partial atelectasis.

Operation—Preoperatively there was little to do for this patient. For three days she received penicillin treatment which we are testing as a routine preoperative measure. She was out of bed and walking around this morning and received no sedation until an hour before operation.

Position of the Patient Anesthesia Venoclysis—The patient is lying on the table on her right side with the left arm thrown upwards over her head. The skin area of the entire left side of the thorax and four inches past the midline front and back has been prepared. She was anesthetized in the anteroom and a tracheal tube was inserted down to and into the right bronchus. She is receiving a cyclopropane oxygen anesthesia delivered under slightly positive pressure directly into the right lung. The pressure gauge is automatic so that if at any time the proper degree of positive pressure is exceeded the valve will open and the pressure will immediately be reduced. At intervals during the operation the anesthetist will allow the lung to become deflated and then will re-expand it.

A venoclysis has been started. At present the patient is receiving glucose solution but later she will receive whole blood and plasma.

Exposure of the Lung—The skin incision starts between the posterior aspect of the scapula and the midline of the back at about the level of the fifth rib and sweeps downwards and forwards in a large curve ending under the breast in about the midclavicular line. The bleeders are tied as they are encountered to guard against the loss of blood. The incision is extended to the muscles baring the thoracic cage. An incision is made over the sixth rib and practically the entire sixth rib is removed. The pleura is opened and the left pleural space is ready for examination. A few adhesions are holding the lung to the chest wall. These are small and will be easily severed. The mass at the left hilus which was seen in the x-ray can be palpated and it feels freely movable. No mediastinal glands can be felt at present nor any metastases in either the visceral or parietal pleura. It appears that the carcinoma has not spread and that the case is operable. Before the pleura

was opened, the left lung was in contact with the left parietal pleura for this woman did not receive a preoperative pneumothorax, a procedure which we have abandoned as being unnecessary.

Now the periosteum over the seventh rib is incised and it will be removed as was the sixth rib. The intercostal vessels under the sixth and seventh ribs are isolated and ligated both anteriorly and posteriorly, and the sixth and seventh intercostal bundles are removed. This gives us a wide incision into the pleural space, allowing us to see the entire field of operation easily. As the rib spreader I use this well known self-retaining abdominal retractor because I have found it more satisfactory than any other rib spreader I have seen. First the lung is mobilized by cutting the few adhesions which I felt between the visceral and parietal pleura. The apex is now completely freed, and the hilus is visualized. With the apex down and the lung completely mobilized except at its base, I can feel that the mass is entirely within the left lung. Again there are no palpable mediastinal glands. By putting the lung on a slight tension a fold of pleura can be seen as it sweeps over the lung, over the hilus and then becomes the mediastinal pleura. This fold is incised and the mediastinal pleura is readily separated in an area that covers the hilus of the lung. There is practically no bleeding.

If this pneumonectomy were for multiple abscesses of the lung for example, my first effort would be to clamp the bronchus so as to avoid spilling the purulent material into the trachea. As it is this does not have to be considered for two reasons. In the first place, there is no sign of either an abscess or a bronchiectasis, and in the second place, having the tracheal tube extend to the right bronchus in itself will prevent the flow of secretions from the left into the right lung. The bronchus may be disregarded for the moment.

Exposure and Ligation of the Left Pulmonary Artery—The dissection of the hilus is started by exposing the left pulmonary artery. The left pulmonary artery is easily visualized under the arch of the aorta. The vagus nerve is clearly visible through the mediastinal pleura as is the branch from the vagus which forms the recurrent laryngeal nerve. The nerve passes between the left pulmonary artery and the aorta just posterior to the ligament, which is the remnant of the ductus arteriosus (Botalli). At this site it is fairly easy to separate the left pulmonary artery from the structures in back of it. The loose areolar tissue which covers the pulmonary artery on its anterior surface is stripped downward so as to expose the lower or caudal surface of the pulmonary artery. Now a blunt nosed curved forceps can be passed entirely around the pulmonary artery with ease. This blunt curved forceps carries with it a suture of No. 1 chromic catgut. The forceps is withdrawn, leaving in its place a ligature around the pulmonary artery. This ligature is tied tightly with a square knot which will not give. The blunt nosed forceps is again passed under the pulmonary

artery and a Kocher hemostat carefully tested to make sure it will not spring is placed between the ligature the lung and the pulmonary artery. A second Kocher hemostat which also has been tested is placed between the ligature and the lung. The pulmonary artery is cut leaving a sufficient stump distal to the ligature so that the ligature cannot slip off. All these large vessels are tied with a single ligature. If the ligature is pulled sufficiently taut and tied correctly it will not slip. I think it is unwise to tie any artery with a so called double ligature because this will leave a portion of tissue completely deprived of its blood supply and this tissue will become necrotic at a place where it is of vital importance that postoperative healing should take place. For those who are uncertain it is more advisable to rethread the suture and transfix the stump distal to the ligature than to tie a double ligature.

Exposure and Ligation of the Left Pulmonary Vein—Now that the pulmonary artery has been ligated and divided the heart is not pumping blood into the lung except through the comparatively small bronchial arteries. In this way when the lung is removed a large amount of blood which ordinarily would be removed with the lung is preserved for the general circulation. Lying just caudal to the pulmonary artery is one of the large left pulmonary veins. The form of these veins is subject to more variation than the pulmonary artery at times the pulmonary vein to the upper lobe which we are not going to dissect may divide so that there will be two or more branches instead of a single vein. Exposing this vein is a much more difficult matter than exposing the artery. The wall of the vein is thinner and more care has to be taken in its dissection. In this instance it appears that the vein is still a unit at the exposed portion of the hilus. With great care the areolar tissue is stripped from the vein. The vein is exposed in the same way that the pulmonary artery was exposed. A ligature is passed around it and the vein is ligated, clamped and severed in the same manner as the pulmonary artery was treated. The pulmonary stumps of both the artery and vein are tied and the hemostats are discarded.

Dissection of the Bronchus—The next structure to be dissected is the bronchus. It can be done more easily with a posterior approach. The intern across the table pulls the lung over towards himself thus exposing the posterior aspect of the hilus. The incision through the hilus pleura which up to now has been over the anterior and upper (cephalad) portions of the hilus is curved and continued downwards along the posterior surface and the pleura is gently reflected towards and away from the lung by blunt dissection with gauze covered finger. The bronchus is covered by a firmer areolar tissue than the structures we have so far encountered. This tissue contains among other things the bronchial arteries and veins which should be saved as much as possible. While the lung is pulled downwards the bronchus is put on

a stretch, and by working both from the front and back the left bronchus is easily exposed. There is a large lymph node overlying the bronchus close to the lung. The gland is soft and therefore was not palpated while the hilus was intact. The node is now dissected away from the bronchus and removed. It has the feeling of an inflamed

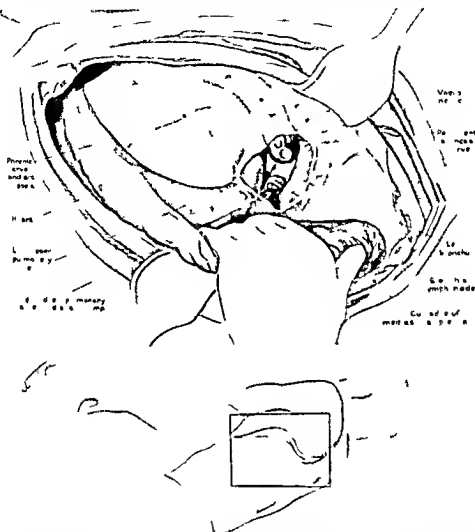


Fig 87—Pneumonectomy—left lung. At this stage the mediastinal pleura has been cut exposing part of the hilus of the lung. The lung is pulled caudalward downwards. The pulmonary artery has been divided and ligated. The pulmonary vein is exposed and also a bronchial lymph gland with the left bronchus just showing underneath.

gland rather than one infiltrated with carcinoma and on section it has the appearance of an adenitis rather than a carcinomatous extension. It is given to the pathologist who will make a frozen section and will report what the microscopic findings are. [A few minutes later it was reported that there was no sign of carcinoma.] It is easy now to reflect more of the mediastinal pleura and examine the mediastinum sev-

eral centimeters above the junction of the left bronchus and the trachea. Except for one or two small soft lymph glands which have the same appearance as the larger one which was first removed, the mediastinum is clear. These two other lymph glands are easily removed and will be kept for section.

The left bronchus is now cleared and ready to be divided. A Kocher clamp is placed about a centimeter and a half from the carina and the bronchus is crushed. Between this clamp and the lung a second clamp is placed to prevent the bronchial secretions from escaping, and the bronchus is severed between the two. The severed ends are sponged to remove any secretions.

The posterior dissection of the hilus is continued, and the pulmonary vein is carefully dissected from the lower lobe. Here again there is apt to be a variation, and there are two branches at this level. These veins as I said before are thin walled and require careful delicate dissection so that they will not be torn. The veins are now ligated individually and severed. The lung is held only by the pulmonary ligament and any adhesions which may be at the base. The pulmonary ligament is carefully dissected before it is cut because often surprisingly large blood vessels are encountered. These may be anomalous vessels arising from intrathoracic vessels, or they perforate through the diaphragm. In one instance I encountered an artery almost as big as my little finger which seemed to come through the diaphragm, and which would have led to a great deal of hemorrhage if it had not been recognized. In this case there are no basal adhesions. The lung is lifted and a clamp is placed on the rest of the pulmonary ligament. The ligament is cut, freeing the lung, which is lifted out of the thorax and passed to the pathologist. The pathologist will open the lung here for macroscopic study.

The pathologist demonstrates the sectioned left lung. There is a hard firm tumor about $1\frac{1}{4}$ or 2 inches in diameter which is obviously carcinoma and which has invaded the lung in an irregular pattern. The left main bronchus is involved at the site of origin of the lower lobe bronchus. This latter bronchus is almost closed by the growth. Attention is called to the apparently normal section of the bronchus between the point of section and the beginning of visible carcinoma.

Closure of the Bronchus and Burial of the Stump—We now come to two very important steps in the operation, the closure of the bronchus and the burying of the stump. The hemostat closing the bronchus is lifted up, and a long silk suture is placed at either end of the stump proximal to the hemostat to act as guy ropes. The area around the bronchial stump is protected with wet gauze. The guy ropes are pulled taut, and the hemostat is removed. The crushed tissue still adheres but is separated with tissue forceps. The stump is now wide open. It is aspirated with a suction tip which is immediately discarded. The bronchus looks normal. A comparatively small amount of air is

escaping, showing that the tracheal tube is well down in the right bronchus. The bronchus is trimmed, removing some of the crushed tissue and what little tissue was left distal to the hemostat. The bronchus is closed with two mattress sutures which approximate the crushed tissue. Three other mattress sutures of silk are placed entering the bronchial walls proximal to the other sutures and thus burying the other sutures when they are tied. The two guy sutures are now tied and the bronchus is completely closed. No more air or anesthesia is escaping. The gauze is removed, the guy sutures are cut and the bronchial stump drops down into the remainder of the hilus.

The entire area is now irrigated with normal saline solution to remove any blood clots, and the wound is inspected. There is no bleeding. The stump of the bronchus lies partially retracted at the upper end of what was the hilus. Below and anteriorly, and below the stumps of the pulmonary veins, lies the pulsating stump of the pulmonary artery. These other few ligatures close off the smaller vessels encountered in the areolar tissue around the bronchus, in the hilus and in the pulmonary ligament. The severed ends of the few apical adhesions which we cut are inspected to be sure that there is no bleeding from them. This inspection is facilitated by a large laryngeal mirror with which the undersurface of the thoracic wall can be seen.

The next step is to bury the bronchial stump. With a few interrupted silk sutures the fairly good flap of mediastinal pleura with its underlying areolar tissue is brought from the anterior surface of what was the hilus to the areolar tissue from the posterior aspect. This buries not only the bronchial stump but in this case also the stump of the pulmonary artery. No attempt is made to close over the lower, caudal part of what was the hilus.

Resection of Phrenic Nerve to Paralyze the Diaphragm—We now have one more step to perform before closing the chest wall, a step which may be forgotten because it is not obvious. This step is resection of about an inch of the phrenic nerve to paralyze the diaphragm. The object of this is not so much to paralyze the diaphragm as it is to diminish the remaining pleural space on the left side because the paralyzed diaphragm rises high into the thoracic cage. The phrenic nerve is clearly seen as it lies on the pericardium. It is easily dissected free with its associated vessels. Ligatures are placed proximally and distally, and about an inch or so is excised.

Closure of the Wound—We are now through with the operation except for the closure of the chest incision. The thoracic cavity is free from blood and the upper part of the hilus is closed over completely, burying the bronchus. The heart is beating firmly and steadily and the pulse is fair.

The chest wall is closed by approximating the cut muscle layers with interrupted sutures of chromic catgut, and the skin is closed with a running suture of black silk. The suture line is covered with a strip

of petrolatum gauze. A fairly large hard rubber catheter is left in the pleural space and it is allowed to protrude through the otherwise closed incision. The end of this catheter is held down in the bottom of a medicine glass filled with water and held low so that no water will run back into the pleural cavity. The anesthetist continues the anesthesia used during the operation, and air bubbles from the end of the catheter. Now that the wound is closed, the chest wall assumes its bellows action, and during each expiration air bubbles from the catheter. Pressure on the abdomen increases the amount of escaping air. After having thus gotten rid of a small amount of air, the catheter is removed. The fact that the pressure of the anesthesia was low, that the catheter was held under an appreciable column of water and that there has been no forced expiration assures me that we have not over expanded the right lung.

Postoperative Care.—The mouth and retropharynx are now carefully aspirated and the tracheal tube is removed while a tracheal aspirator is used. The anesthesia is stopped. The patient will receive intranasal oxygen as long as she is in the operating room and on the cart, and she will be put to bed under an oxygen tent.

She will be placed on her operated side before she is awake, and after she is awake she will be encouraged to lie on her left side most of the time. Since most of these patients are partially awake before they reach their rooms, they are placed on their operated side while being lifted from the operating table to the cart. The rest of the treatment is mainly symptomatic. Pain is treated with small doses of morphine. Shock, if it occurs, is combated with intravenous infusions of glucose, saline, whole blood and plasma. The oxygen tent is continued usually for twenty four or forty eight hours or longer if there is dyspnea. Food is given by mouth as soon as tolerated and in amounts as tolerated. The patient will be allowed to sit up in bed by the second or third day if she wishes and will be out of bed as soon thereafter as she is strong enough—probably in the sixth or seventh day.

Of late we have been placing 40,000 or 50,000 units of penicillin in normal saline twice daily into the chest cavity. This patient will get her first dose after the catheter is removed while she is still in the operating room. This is done by means of a syringe and needle. We have been continuing this for the first two or three days postoperatively, then waiting until the sixth day and repeating the procedure for three more days. It is probably about the fifth or sixth day that the danger of a leak of the bronchial stump is greatest. The sutures will keep the stump closed for that length of time. On the fifth or sixth day the bronchial stump used to open in the experimental animals upon whom I performed pneumonectomies before I realized that the bronchial stump had to be buried. The use of penicillin is still in the experimental stage. At the present time I think that we have had much smoother convalescences and no empyemas except in

grossly infected cases since we have used penicillin preoperatively, postoperatively and intrapleurally.

The fluid which will collect in the left chest also can be treated symptomatically. As long as the fluid is not infected and is not causing respiratory difficulty by undue deflexion on the mediastinum or cardiac embarrassment by undue pressure on the heart, it is beneficial, as Rhienhoff has shown. In about half of the cases we never have to withdraw any fluid, and in many of the rest the small amounts that have been withdrawn may not have done much good.

THE SURGICAL REPAIR IN VARIOUS TYPES OF DIAPHRAGMATIC HERNIA

JOHN M. DORSEY, M.D.*

EMBRYOLOGY OF THE DIAPHRAGM

In discussing the surgical repair of diaphragmatic hernia, it is important first to consider the embryologic formation of the diaphragm. The various failures of this process lead to the varieties of hernia which we are called upon to deal with. Bremer¹ has described the embryology of the diaphragm as follows:

The diaphragm in man consists primarily of the septum transversum, a sheet of connective tissue which, in very young embryos, forms the caudal limit of the pericardial cavity, and stretches from the ventral and lateral body walls to the ventral wall of the foregut (later esophagus). Behind the dorsal edge of the septum on either side of the foregut the pericardial cavity connects freely with the peritoneal cavity. The two passages thus formed are to lodge the lungs and may be called the pleural passages. Each becomes cut off from the pericardial cavity by the simple growth from the lateral wall of a thin membrane which ultimately reaches and fuses with the lateral wall of the

thick upper and thin lower sheet. This part I have called the dorsal septal extension. The fusion of the three edges of the extension, dorsal, lateral and mesial, with the body walls and mediastinum to effect complete closure is, however, not simple. The dorsal edges fuse with the tops of the adrenal glands which being large and precocious in man, bulge forward from the dorsal wall to meet them. The lateral edges meet the pleuro-peritoneal membranes, structures which form the covering walls of small niches in the lateral walls. The two mesial edges have differing histories. On the right side a tubular niche develops in the wall of the mediastinum lying in the pulmonary ligament and the septal extension meets and fuses partly with the mediastinum and partly with the membrane covering this niche. On the left side the stomach swings far to the left crowding aside the dorsal lobe of the liver and its septal extension. Only after the stomach has descended lower in the abdomen do the hepatic lobe and the septal extension grow over it. The extension then fuses with the mediastinum directly.

The septal structures form only the membranous portions of the diaphragm. The muscular parts are formed by the burrowing of the expanding pleural cavities into the body wall in such a way as to strip off the inner layer of muscle and fascia which then forms the peripheral part of the diaphragm. The burrowing starts from two points with a slight gap between and proceeds in two directions, first from behind the adrenal gland pushing caudally and mesially and second, from the dorsolateral angle of each cavity extending around the ribs to the anterior thoracic wall. The muscles peeled off by these

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two separate processes later fuse edge to edge, leaving at the gap a triangular area peripherally, later closed by fibrous tissue and known as the trigonum lumbocostale.

The completed diaphragm is thus a complicated structure, the result of a long series of developmental processes of diverse nature. In such circumstances it is almost axiomatic embryologically that the later steps in the process will be most subject to anomalous changes. One might expect, therefore, that the most common form of diaphragmatic hernia would be through the trigonum lumbocostale—the so called foramen of Bochdalek.

DIAPHRAGMATIC HERNIA IN INFANCY AND CHILDHOOD

Our clinical experience has been in accord with the foregoing conception of the embryology of the diaphragm. It is in the period of infancy and childhood that the clinical signs of this defect appear. The newborn infant may die from asphyxia or from aspiration pneumonia before the abnormality is recognized. The loops of bowel misplaced in the thoracic cavity, incarcerated or at least retained there by the negative intrathoracic pressure either embarrass respiration enough to produce death from asphyxia or cause regurgitation of stomach contents into the respiratory tract. If death does not occur as a result of either, bowel obstruction may supervene. Occasionally a child will survive all of these, as illustrated in the following case.

CASE I—J. A. S. a 4 year old girl, entered Presbyterian Hospital on April 24, 1939 because of impaired physical development. Her parents had consulted a pediatrician who observed a visible cardiac impulse far to the right and an absence of breath sounds in the left pulmonary base associated with hyperresonance, and an abdomen which was much less full than normal. A ray of the chest was ordered and this appears as Figure 88. It was obvious that the clouding of the entire left lung field was due to the presence of loops of bowel above the diaphragm. Figure 89 is that of chest after a barium enema. The colon from the midportion proximally is within the left pleural space and Figure 90 shows that in the lateral view, loops of small bowel are also present.

Operation—Repair of the developmental defect was recommended and this was carried out as follows:

On April 26, through a 1 inch long incision 1 fingerbreadth above the left clavicle, the anterior scalene muscle was approached in the usual manner. The phrenic nerve in this instance was found to be a firm filamentous strand running downward and medially on the muscle. It was crushed with a small pointed forceps. Fluoroscopy on the next day showed the left diaphragm to be elevated and moving paradoxically on respiration. On April 28, under ethylene anesthesia, the scaphoid abdomen was incised and, through a left upper paramedian incision, the left rectus muscle was reflected laterally and the peritoneal cavity entered. There was an almost complete absence of the normal abdominal contents. The entire jejunum, the terminal ileum, the cecum and ascending colon including the appendix and the proximal two thirds of the transverse colon as well as the spleen were found to be in the left thoracic cavity, gaining admission by way of

Fig 88



Fig 89



Fig 90

a defect through the *trigonum lumbocostale*. A small catheter was placed through this opening to equalize the abdominal and thoracic pressures to allow by gentle traction these viscera to be removed from their abdominal position. The defect in the diaphragm was approximately 6 cm. long. There was no hernial sac present. The edges of the defect were freshened and closure was made by imbricating the edges of the paralyzed diaphragm over one another with interrupted mattress sutures of double braided silk. Additional interrupted silk sutures completed the overlapping closure of the diaphragm, as the catheter was withdrawn with the placement of the last suture.

The operation up to this point was performed under ethylene anesthesia. Because it was readily apparent that the viscera previously in the chest could not be replaced into the abdomen without too great tension, it was decided to dilate the abdominal wall manually under deep ether anesthesia such as I have described,¹ so that closure might be more readily effected. This was accomplished without difficulty.

The child was given 300 cc. of citrated whole blood during the course of the operation and was returned to her bed to be placed in oxygen. The abdominal wound was closed in layers in the usual fashion, using three silkworm sutures for tension. Her postoperative course was uneventful, and a roentgenogram of the chest eighteen months after operation showed a high left diaphragm but an otherwise normal chest.

Comment—Careful investigation of the earlier history of this child's difficulty revealed the fact that x-rays of the chest within a few days after birth did not disclose the presence of a diaphragmatic hernia. This developed at a later date, probably within the first few months of life. The child's respiratory system was able to compensate for the impairment of function of the collapsed left lung, but her general development was retarded. The fact that the abdominal viscera did not occupy their normal position led to a greatly reduced abdominal capacity. If replacement of these viscera had been carried out without dilatation of the abdominal cavity, it is doubtful whether the child would have withstood the anoxemia which might have developed from the respiratory embarrassment produced by the upward pressure on the diaphragm of viscera in a space too small to contain them. It is this difficulty which led Ladd and Gross² to describe a two-stage operation for the repair of diaphragmatic hernia in infants. At the first stage the replaced viscera are enclosed only by the skin and subcutaneous

Fig. 88 (Case I)—Clouding of the entire left lung field with displacement of the heart shadow to the right due to diaphragmatic hernia through left foramen of Bochdalek.

Fig. 89 (Case I)—Barium enema revealing opacity to be due to colon from midtransverse portion to cecum plus loops of small bowel.

Fig. 90 (Case I)—Lateral view of same showing posterior location of hernial opening. The cecum and appendix can be identified just anterior to vertebral bodies.

tissue of the abdominal wall. These are sutured carefully with interrupted silk. At the end of six to seven days the wound is reopened and a careful layer-by-layer closure is made after more physiologic stretching of the abdominal wall has taken place during the interval. There is a hazard in this method of management and that is the danger of evisceration during the time between the first and second stages. In the case of the patient above described this method had not as yet been reported and the manual dilatation of the abdominal wall was carried out because of the recognized need for greater space.

Because the presence of the largest part of the liver on the right seems to help in the closure of the *trigonum lumbocostale*, we see *right sided* Bochdalek foramen hernias in children much less frequently. However, it is quite possible for them to occur in the same fashion as on the left side.

CASE II—D. L. H., an 8 weeks old infant, was brought to the Presbyterian Hospital in March 1942 with a history of a sudden onset of respiratory difficulty accompanied by cyanosis. It was suspected that the child had pneumonia, and an x ray of the chest was ordered. Figure 91 is an x ray of the child's chest showing air in loops of bowel above the right diaphragm. The right lung is partially compressed and the heart displaced to the left. In Figure 92 a lateral view of the chest reveals the loops of bowel to enter the thorax through a posteriorly located opening. The preoperative diagnosis of diaphragmatic hernia through the foramen of Bochdalek was made and immediate surgery advised.

Operation—In the short preoperative period, fluid balance was restored by intravenous administration of 10 per cent glucose in normal salt solution. The child was then given gas anesthesia with a tight fitting mask, and the abdomen was opened through an upper paramedian incision. It was possible to displace the liver enough to palpate and visualize an opening in the posterior diaphragm through which loops of small bowel entered the thoracic cavity. By gentle traction these were brought back into the abdominal cavity. It was then necessary to alter the previous incision by transversely dividing the right rectus muscle. This gave adequate exposure of the diaphragmatic defect and allowed for its simple closure with several interrupted silk sutures. The abdominal wall was then closed in the fashion advocated by Ladd and Gross. The abdominal incision was secondarily closed at the end of six days, and the patient's convalescence thereafter was quite uneventful. Figure 93 is that of a lateral roentgenogram of the chest postoperatively, showing the sharp line of the repaired diaphragm with air containing viscera below. Figure 94 is another postoperative roentgenogram of the chest made two years later, demonstrating the adequacy of the repair.

Comment.—The surgical repair of the right- and left-sided diaphragmatic hernias, the former in an infant of 8 weeks, the latter in a child of 4 years, was carried out in each instance through an abdominal incision. It is quite possible in infants and young children to obtain ade-

Fig 91



Fig 92



Fig 93

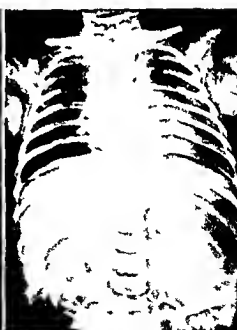


Fig 94

Fig 91 (Case II) —Roentgenogram of chest of eight week old infant showing air in loops of bowel above right diaphragm. The right lung is partially compressed and the heart displaced to the left.

Fig 92 (Case II) —Lateral view of Figure 91. Note the posterior entrance of bowel loops into the thorax and the relative anterior position of the liver shadow.

Fig 93 (Case II) —Lateral roentgenogram of chest postoperatively. Note the sharp line of repaired diaphragm with air containing viscera below.

Fig 94 (Case II) —Anteroposterior view of chest two years postoperatively. No evidence of recurrence of hernia. Both sides of diaphragm sharp in outline.

quite exposure of the diaphragm through the abdomen. Retraction and packing off of abdominal viscera readily accomplishes this purpose. It is interesting to note that whereas the liver shadow in infants as demonstrated in Case II may be quite sizable in the anteroposterior direction, still from the lateral aspect the liver is shown to occupy an anterior location allowing for free exposure of the diaphragm on the right. This was contrary to my previous expectation. On the left side as in Case I, it was not necessary to deal with the liver, so we were confident that the abdominal approach would be quite satisfactory. It cannot be too strongly recommended that immediate surgical repair of this type of diaphragmatic hernia should be carried out, whether the defect be right or left sided. Procrastination with the excuse of improving conditions of nutrition and hydration except in the immediate preoperative period should be avoided. These infants seem to stand anesthesia and surgery quite satisfactorily.

DIAPHRAGMATIC HERNIA IN THE ADULT

The second most common diaphragmatic hernia is in the region of the central tendon tendinous centrum on the left side near the esophagus. The organ most frequently involved is the stomach. This is referred to as a hernia through the dome or through the esophageal hiatus. It is due to the failure of the last step in the closure of the pleural passage, the growth above the descending stomach of the thin strip of liver and septal extension to join the mediastinum. Except for the large opening, the diaphragm in this type is normal. In addition, other types of defects may be seen in the adult, such as herniation through the anteriorly placed foramina of Morgagni. There may also be found malformations of the lumbar sector of the diaphragmatic muscles leading to complete absence of one or both dorsal lobes. Through such large openings many of the underlying organs could pass. These are all congenital defects. In the adult too, we see acquired hernias from trauma such as bullet wounds and stab wounds, thoraco-abdominal injuries of various kinds and the rare herniation following subphrenic abscess.

The most commonly encountered diaphragmatic hernia in the adult is the one alluded to in the region of the esophageal hiatus. The symptoms of this hernia may not manifest themselves until the various forces producing increased intra-abdominal pressure in the adult, such as pregnancy, constipation, severe coughing or trauma, may cause the stomach to occupy the hernial sac previously present. It is this particular problem which we encountered in the following case:

CASE III—Mrs. D. M. entered the Presbyterian Hospital in January, 1945, complaining of nausea and vomiting associated with epigastric pain after food taking.

Operation.—Surgical repair was decided upon and with the patient lying on the operating table, left side uppermost, the left eighth rib

Fig 95



Fig 96



Fig 97

Fig 95 (Case III) —Anteroposterior roentgenogram showing barium in portion of stomach above diaphragm. Whereas this appears to be on the right side, it is actually posterior mediastinal in location.

Fig 96 (Case III) —Spot film of Figure 95 showing large esophageal hiatus type of hernia of stomach filled with barium.

Fig 97 (Case III) —Postoperative fluoroscopic view of stomach. The left diaphragm is high due to phrenic nerve interruption at time of surgery, but stomach is well below it.

was resected from angle to the costal cartilage. The pleural space was opened widely through the bed of the resected rib. The left lung was found to be free of adhesions to the parietal pleura, collapsed when

the chest was opened and was packed out of the operative field after division of the pulmonary ligament. Under the mediastinal pleura anterior to the aorta and behind the pericardium could be palpated the posterior mediastinal hernial sac containing stomach. This sac extended to the right of the midline, as was quite evident in the fluoroscopic studies. The phrenic nerve was crushed as it coursed from the pericardium to the diaphragm. The pleura over the sac was incised exposing the sac itself. This was completely divided in its entire circumference, allowing the upper portion to remain within the chest and the lower portion to remain attached to the stomach. This left a region of stomach wall denuded of serosal covering. The edges of the esophageal hiatus were freshened and the hiatus itself was closed snugly about the terminal esophagus through which had been led a normal size stomach tube. This was to prevent closure which might be too snug. The sutures immediately adjacent to the esophagus were of catgut to allow for subsequent dilatation of the hiatus should dysphagia occur.

The rest of the closure was carried out with heavy braided silk mattress sutures, imbricating the edges of the opening over one another. A catheter was then placed through a stab wound in the posterolateral chest wall and the thoracic wall closed in layers. Multiple interrupted sutures of No. 2 black silk were used on the intercostal muscles and tied as the ribs were held together by a rib approximator. The muscles of the thoracic wall were then closed with interrupted catgut sutures and the skin with running silk. The patient was returned to her room and placed in an oxygen tent. The catheter leading from her chest wall was attached to a Wangenstein gravity aspirator.

Postoperatively, penicillin was administered in doses of 30 000 units every three hours for four days. The patient was removed from the oxygen tent at the end of forty eight hours, the catheter was removed from her chest after a portable x ray had demonstrated that the lung had completely re-expanded on the fourth day. The patient was out of bed on the fifth day and left the hospital ten days after the operation. Figure 97 is a roentgenogram of the chest and abdomen after a barium meal postoperatively. Whereas the left diaphragm is elevated because of the previous phrenic nerve interruption, it is quite clear that the stomach is entirely below the diaphragm.

Comment—It is essential that the exact anatomy of the hernial sac be understood to insure proper surgical handling. There are, for purposes of simplicity, three layers which contribute to the formation of the sac. They are, first, the peritoneal reflection of the peritoneum onto the cardia of the stomach. This goes to form the gastrophrenic ligament. In those individuals with enlarged esophageal hiatuses this reflection is at a lower level on the stomach. As the stomach herniates into the posterior mediastinum, this becomes the innermost layer of the sac. Just external to this is the thicker fibrous diaphragmatico-

esophageal membrane. Between the two may be loose adipose tissue. The outermost layer is the mediastinal pleura. All of these coverings must be divided to denude the stomach and allow for effective closure of the diaphragm about the esophagogastric juncture.

With the advent of esophagogastrostomy as the successful surgical treatment for carcinoma of the lower esophagus, it has been necessary for surgeons in completing this operation to produce a diaphragmatic hernia. Similar in location to the type described in the preceding case, it differs however in that no sac is present. Probably for this reason it does not tend to increase in size as does the sliding type of hernia.

CASE IV—A 40 year old male Negro had complained of dysphagia of two months' duration. Esophagoscopy proved the irregular defect above the diaphragm to be a squamous cell carcinoma. Through the usual transthoracic approach, the lesion was resected and intestinal continuity re-established by end-to-side union of the esophagus to the stomach at the level of the aortic arch. It was necessary in this instance to perform the procedure described by Garlock of removing the esophagus from its bed beneath the aortic arch and bringing it over the aortic arch to allow for anastomosis without tension with the stomach. A lateral roentgenogram of the chest after ingestion of barium showed that the stomach was as high as the midthorax.

These patients in whom it is necessary to bring a large portion of the stomach above the diaphragm, complain of the symptoms which we recognize as being due to diaphragmatic hernia, but they may be allocated by careful dietary management to allow for reasonable comfort considering the magnitude of the underlying condition for which operation was done.

Comment—In adults many esophageal hiatus hernias are seen which may be asymptomatic or which may produce symptoms of a very mild nature. As has been pointed out by Harrington, diaphragmatic hernias of this type may mimic the symptoms of gallbladder disease, duodenal ulcer, coronary disease or any condition of the upper abdomen. Needless to say, even though diaphragmatic hernia is found, it is absolutely necessary to rule out other conditions with which it may be associated. Indeed, some authors believe that the production of diaphragmatic hernia in certain individuals is due to a reflex vagal stimulus arising from some upper abdominal disease process, such as cholecystitis or duodenal ulcer, which causes a shortening of the esophagus and tends to pull the stomach into the thorax.

Diaphragmatic hernias with mild symptoms need not necessarily require surgical correction. Careful medical management involving dietary restriction, such as avoidance of gas-producing foods, multiple small feedings, with emphasis on a particularly light evening repast, may sufficiently relieve the symptoms of distress so that surgical intervention may be avoided. After all, a procedure of this magnitude carries with it a definite risk which must be weighed against the severity

of the complaint, taking into consideration the age and general condition of the patient at hand

When symptoms are pronounced, however, and relief is not obtained by ordinary medical measures, surgery should be resorted to. It is my feeling that in the average adult, with the improvement in anesthesia, the advent of penicillin, the increasing experience in thoracic surgery and the ease of repair because of more readily obtained exposure through a transthoracic incision, surgery is the proper course. It is difficult to improve upon the results of surgery of diaphragmatic hernia as reported by Harrington,⁴ most of whose procedures have been done through the abdomen. Except in exceptional cases, however, these esophageal hiatus hernias may be approached through the chest with much greater ease to the surgeon and no more risk to the patient. Furthermore, patients with thoracic wounds may be gotten out of bed perhaps a little earlier than those with abdominal incisions and this will tend to further diminish the pulmonary complications. This is all in contradistinction to the surgery of diaphragmatic hernia in children, where exposure and ease of operation can be accomplished quite adequately through the abdomen.

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SURGICAL TREATMENT OF MALIGNANT TUMORS OF THE DUODENUM EXCLUSIVE OF THOSE ARISING FROM THE PAPILLA OF VATER

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MALIGNANT neoplasms of the duodenum exclusive of those arising in the papilla of Vater or its immediate vicinity are regarded as rare. The incidence at postmortem examination has been variously estimated from one case in every 3000 to one case in every 31,000 autopsies.

These neoplasms are classified as to their location in respect to the papilla of Vater. Those in the first and upper segment of the second portions of the duodenum are referred to as "suprapapillary", those below the papilla, as "infrapapillary" growths.

The number of reported resections of malignant tumors in the duodenum is few indeed. A review of the literature up to 1942 reveals that in seven instances of suprapapillary carcinoma, four of the patients survived operation, one reported himself still well seven and one-half months later. Up to 1945 there were sixteen resections of infrapapillary carcinomas, one patient died six years after operation and three lived twelve, fifteen and twenty months respectively. Up to 1945 there have been five instances of resection of sarcoma of the duodenum with survival of two, four, five and twenty-six days and of nine months (this death from metastases) respectively. Because of their rarity, primary malignant neoplasms of the duodenum are usually not considered in the differential diagnosis of upper abdominal malignant tumors. Their clinical manifestations are those of obstructing neoplasm of the pylorus and in most instances this has been the preoperative clinical impression. Roentgenographic examination of the stomach and duodenum, however, permits of the accurate localization of the tumor, unless it is in the first segment of the duodenum just beyond the pylorus, in which instance differentiation from neoplasms of the latter may not be possible. The number of primary malignant neoplasms of the duodenum seen by any one operator being limited, experience has not yet been sufficient to warrant general conclusions in regard to the surgery of these growths. The following account is a record of what was done in a personal series of five patients with malignant neoplasms of the duodenum†. Surgical attack consisted of (1) resection of the

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tumor and portions of the duodenal wall involved (2) resection of a segment of the duodenum and adjacent segment of the head of the pancreas, and (3) pancreatoduodenectomy to resect the entire duodenum and head of the pancreas

RESECTION OF THE TUMOR

CASE I (F K) Roentgenograms revealed a polypoid tumor mass in the lower portion of the second segment of the duodenum (Fig 98)

Operation (Fig 99) —1 An upper midline incision was used

2 The transverse mesocolon arising from over the head of the pancreas was transected at its base care being exercised to avoid injury to its vessels and reflected downward to permit exposure of the entire duodenum and head of the pancreas

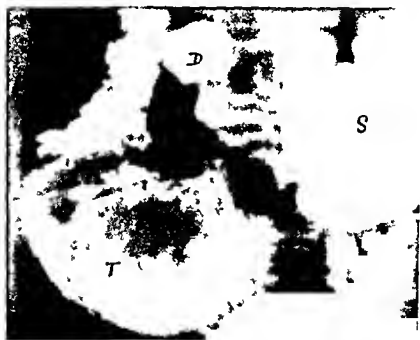


Fig 98 (Case I) Roentgenogram showing S pyloric portion of stomach D duodenal bulb T large papillomatous tumor in second portion of duodenum (Courtesy American Journal of Surgery)

3 A longitudinal incision was made through the anterior wall of the second and first portions of the third segment of the duodenum to expose an ulcerated rounded tumor mass bulging forward from the posterior mesial wall of the duodenum The papilla of Vater was not identified

4 The tumor was grasped by the left hand and pulled upward

bringing with it the surrounding duodenal wall. With scissors in the right hand transection of the duodenal wall about the base of the tumor was carried out beginning beyond its distal (lower) pole. As this proceeded it became apparent that the entire thickness of the duodenal wall and underlying pancreatic tissue was being incised. With the last cut of the scissors, a gush of clear fluid and then bile occurred. The terminations of the common duct and main pancreatic duct had been transected. Thus the papilla of Vater had been secondarily involved by the growth.

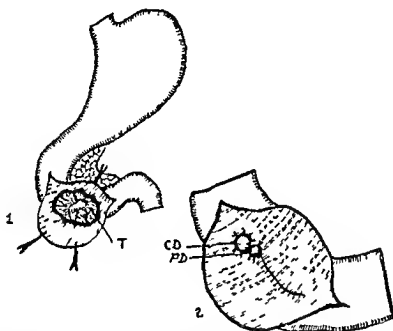


Fig 99 (Case I)—(1) Exposure of carcinoma, *T*, in second portion of duodenum by longitudinal incision in bowel wall (2) Repair of resected portion of postero-mesial duodenal wall by one layer of interrupted sutures. *CD* and *PD*, Transected common bile and main pancreatic ducts respectively sutured into upper angle of wound. The resected tumor arose in the lower portion of the second segment of duodenum and involved papilla of Vater secondarily (compressed it upward but did not infiltrate into it). Patient well seven years and 10 months after operation.

5 The elliptical defect in the posterior wall of the duodenum was closed by a single layer of through and-through interrupted silk sutures which included pancreatic tissue.

6 In the upper angle of the above wound the common bile and main pancreatic ducts were sutured to each other by two sutures and then into the duodenal wall by interrupted sutures, finally closing the wound completely.

7 The incision in the anterior wall was closed by two layers of interrupted silk sutures.

8 The abdominal wound was closed in layers without drainage.

Histopathologic Study—Medullary carcinoma of the duodenum. The small polyhedral cells resembled those of a carcinoid yet did not afford reduction of

ten months after operation

SEGMENTAL RESECTIONS

Upper Duodenum

CASE II—Roentgenograms revealed a stenosing lesion that was thought to be in the terminal pylorus (Fig 100). At laparotomy a scirrhous carcinoma was found involving the first segment of the duodenum and infiltrating downward into the head of the pancreas. There were no apparent metastases.



Fig 100 (Case II)—Roentgenogram showing S pylorus D rigid and deformed first segment of duodenum containing carcinoma B duodenum beyond neoplasm

Operation—Excision of the growth was carried out as follows (Fig 101)

1 The lower stomach was mobilized. Rubber covered clamps were applied at the junction of the lower third with the upper two thirds and the stomach was divided.

2 The pylorus was reflected to the left and an incision made into the head of the pancreas to free its upper anterior third with the duodenum since that portion of the head of the pancreas was involved by the duodenal growth.

3 The first segment of duodenum with adherent portion of the head of the pancreas was completely mobilized as was the upper third of the second segment. Care was exercised to avoid injury to the subjacent common bile duct and portal vein.

4 The duodenum was transected at the junction of the lower two-thirds of the second segment with its upper third. The distal segment was ligated and the stump invaginated with two concentric purse-string sutures of linen. The lower stomach and upper portions of duodenum with adherent part of the head of the pancreas were removed.

5 Examination of the raw surface of the head of the pancreas revealed no gross evidence of the main pancreatic duct. This surface was compressed by interrupted silk sutures taken through the margins of the incised area.

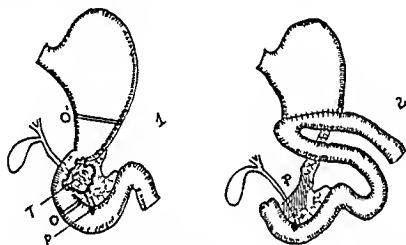


Fig 101 (Case II) —(1) T, Carcinoma in first segment of duodenum invading upper anterior aspect of head of pancreas O and O. Lines of transection in stomach and second portion of duodenum. P, Papilla of Vater not injured. (2) Situation after resection showing Polya gastrojejunostomy (posterior) and P (shaded area) resected surface of upper portion of head and neck of pancreas. Main pancreatic and common bile ducts were not injured.

6 Posterior Polya gastroenterostomy was performed.

7 The abdominal wound was closed in layers with two large soft rubber drains to the site of incised pancreas. The postoperative course was uneventful and the drains were removed on the fifth day.

Pathologic Study—The mucosa of the first segment of duodenum was replaced by an elongated ulceration 3 cm in length with raised rolled borders of edematous mucosa. This extended proximally to the pyloric sphincter, not beyond. The floor of the ulcer was gray and firm and beneath it in the resected portion of the head of the pancreas there was marked induration which however did not extend to the limits of resection. Histologic study revealed adenocarcinoma arising in the first segment of duodenum and infiltrating the subjacent pancreas.

Subsequent Course—The patient was well for one year, then presented a palpable epigastric mass that was moderately tender. Laparotomy was again performed at which time a dense fist size mass of recurrent carcinoma was present.

over the head of the pancreas. In the attempt to resect this the portal vein was opened and its ligation was necessary. The operation was rapidly terminated by closure of the abdominal wound in layers. The patient was returned to her room and succumbed in shock three hours later.

Lower Duodenum

"portion
space"

Operation—Excision of the growth was carried out as follows (Fig 103)

1 A high midline incision was employed. A double fist size rounded tumor mass was found involving the posterior wall and convex border of the third segment of duodenum extending backward behind the



Fig 102 (Case III)—Roentgenogram of D second and T third portions of duodenum U Large ulceration due to spindle cell sarcoma of wall of third portion of duodenum E Barium that entered necrotic center of tumor ulcerating at U

uncinate process and lower portion of the head of the pancreas into the retroperitoneal space. It also bulged to the right into the root of the upper portion of the mesentery of the jejunum almost completely surrounding the superior mesenteric vessels.

2 The ligament of Treitz was transected to mobilize the duodeno-jejunal junction. The right half of the transverse mesocolon was transected and the mesocolon reflected downward. The posterior parietal

peritoneum along the convex curvature of the duodenum was incised to mobilize the duodenum and head of the pancreas

3 The inferior border of the tumor was dissected upward This elevated the lower duodenum and head of the pancreas The superior mesenteric artery and vein were dissected out of that part of the tumor that partially surrounded them

4 The jejunum was transected about 3 cm beyond the ligament of Treitz and the distal end invaginated by two concentric purse-string sutures A small Payr clamp was then passed horizontally from left to right across the duodenum about 1 cm below the midpoint of the second segment and across the head of the pancreas at the junction

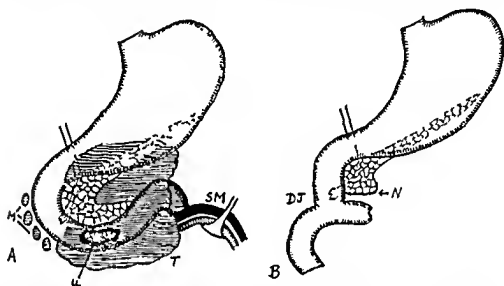


Fig 103 (Case III) —A, Findings at operation T, Large spindle cell sarcoma arising from third portion of duodenum with ulceration at one point (U) SM, Superior mesenteric vessels partially surrounded by neoplasm The latter also extended posteriorly and superiorly behind head and body of pancreas M, Metastatic lymph nodes along greater curvature of duodenum

B, Termination of operation DJ, Duodenojejunostomy N, transected lower portion of head of pancreas

of the upper and lower halves and closed The inferior pancreatoduodenal vessels were isolated and transected near the superior mesenteric trunks Before the crushing clamp was closed the superior mesenteric vein was retracted to the right to avoid injury The head of the pancreas was transected below the crushing clamp This permitted greater access to the superior surfaces of the tumor and the latter was then dissected out of its bed and removed after dissection with it of several enlarged lymph nodes along the greater curvature of the duodenum

5 The crushing clamp was then removed and the opened inside of the second segment of duodenum inspected The papilla of Vater was readily identified about 1 cm above the level of duodenal transection The main pancreatic duct was probed backward through the ampulla

of Vater and found to be uninjured. The crushed margin of pancreatic tissue was sewed over with interrupted silk sutures.

6 The upper closed jejunal segment was brought to the left and duodenojejunosomy performed, end to side with two rows of silk sutures. Small "lites" were taken along the posterior rows to avoid if possible, inclusion of the papilla of Vater.

7 The abdomen was closed with two large soft rubber drains to the site of transection of pancreatic tissue.

Pathologic Study—The tumor mass measured 11 by 7 by 3.5 cm. Adherent to the inferior surface was a segment of duodenum 12 cm in length, a segment of jejunum 3 cm in length and segment of head of pancreas 5 by 3 by 3 cm. On the posterior wall of the opened duodenum was an elongated ulceration 3.5 by 2 cm with ragged raised edges. Hemorrhagic material exuded from the ulceration and probing revealed a deep sinus leading into the center of the tumor mass which was itself necrotic. This fistulation of the tumor mass into the duodenum appears to be characteristic of sarcomas of this segment of bowel. Histologic section revealed the tumor to be a large spindle cell sarcoma. Sections of several lymph nodes revealed metastatic sarcoma.

Subsequent Course—The patient is alive and well three years after operation.

EXCISION OF THE ENTIRE DUODENUM PANCREATODUODENECTOMY

Extensive malignant neoplasms of the duodenum require complete excision of the duodenum. This can be accomplished only by concomitant resection of the head of the pancreas and therefore its excision must also be carried out. Pancreatoduodenectomy was originally devised for resection of the carcinomas of the head of the pancreas; however, large duodenal neoplasms will usually involve the head of the pancreas and therefore this operation is also indicated for such growths.

CASES IV AND V—Two patients (G. M. and C. T.) were subjected to pancreatoduodenectomy. The former had a round cell sarcoma or lymphosarcoma involving the duodenum from the upper curvature to near its termination (Fig. 104), and the latter had a carcinoma of the third segment of duodenum invading the adjacent lower portion of the head of the pancreas and its uncinate process (Fig. 105). The former patient, who was in a very poor nutritional state, died on the seventh postoperative day and the latter lived three months following operation, but succumbed from a deep abdominal abscess that developed after he returned home.

Operation—The details of pancreatoduodenectomy are as follows (Fig. 106):

1 A high midline or reverse L incision is employed.

2 The duodenum and head of the pancreas are mobilized by incision of the posterior parietal peritoneum along the greater curvature of the duodenum.

the pylorus and
duodenal vessels are



Fig 104 (Case IV) —Roentgenogram showing, *P*, pylorus, *B*, duodenal bulb, *DD*, deformed and semirigid second and third portions of duodenum whose walls are infiltrated by lymphosarcoma



Fig 105 (Case V) —Roentgenogram of entire duodenum *B*, Duodenal bulb, *S*, second portion of duodenum, *UT*, ulcerating carcinoma of third segment of duodenum, *D*, terminal segment of duodenum

4 The neck of the pancreas is carefully elevated from the anterior surface of the superior mesenteric vein and transected

5 The jejunum is transected just distal to the ligament of Treitz after its severance, followed by invagination of the distal jejunal segment

6 The terminal portion of the duodenum is retracted to the left from beneath the superior mesenteric vessels

7 The head of the pancreas and the duodenum are removed

8 A posterior Billroth II gastrojejunostomy is done

9 The first long loop of jejunum is elevated for anastomosis with biliary tract (see below)

10 After the above anastomosis, enteroenterostomy is carried out between afferent and efferent loops of jejunum going to bile tract

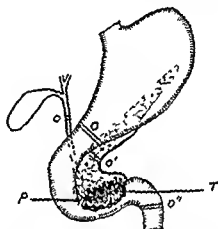


Fig 106 (Case V) —T, Carcinoma of third segment of duodenum with invasion of head of pancreas and uncinate process P, Papilla of Vater O O, O* O* Lines of transection for excision of neoplasm and its extension one-stage pancreatoduodenectomy

anastomosis This is performed below the transverse mesocolon if the loop of jejunum was brought through a hiatus in this mesentery otherwise it is performed about 15 cm below the above mentioned bile tract-jejunal anastomosis The abdomen is closed in layers, with soft rubber drains to the site of the head of the pancreas

Management of the Transected Neck of the Pancreas (Fig 107) —Previously in patients with carcinoma of the ampulla of Vater and head of the pancreas I have simply ligated the transected neck with interlocking mattress sutures of silk The pancreatic duct was ligated separately. Pancreatic fistulas were expected and accepted and persisted for several weeks to months To obviate this, burial of the stump into the afferent loop of jejunum brought up for bile tract anastomosis has been carried out as follows The stump of the pancreas is treated as

described. An incision is then made through the serosa of the jejunal wall and the muscular fibers separated slightly. The posterior edge of the slit is sutured by interrupted sutures to the posterior margin of the transected neck of the pancreas. A small stab wound (2 mm in length) is made through the jejunal wall into the lumen and the ligated pancreatic duct is sewed into this with one suture. The anterior margin

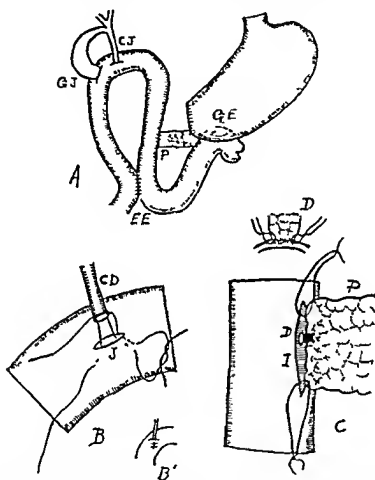


Fig 107 (Case V) — (A) Showing reconstitution of upper alimentary tract after one stage pancreatoduodenectomy. CJ, Choledochojejunostomy, GJ, cholecystojejunostomy, GE, gastrojejunostomy (Billroth II), P, implantation of transected neck of pancreas into jejunum, EE, jejunojejunostomy. (B) Showing method of implanting common duct, CD, into jejunum through stab wound J. (B') Serosal sutches fold jejunal wall over implantation site.

of the pancreatic stump is then sutured to the anterior margin of the serosal slit in the jejunal wall. This procedure was carried out in two patients. In one (not reported in this series) the wound healed without pancreatic fistula. In the other (Case V) a fistula developed.

Most patients do fairly well with pancreatic juice occluded from the bowel. Those presenting steatorrhea are given pancreatin by mouth.

Bile Tract Jejunal Anastomosis (Fig 107)—Ligation of the common bile duct and cholecystogastrostomy or cholecystojejunostomy are attended with the danger of reopening of this duct with resulting fatal bile peritonitis. Because of this, choledochojejunostomy has been advocated in recent years in connection with pancreatoduodenectomy. Where, in the absence of obstruction to the common bile duct, the latter is not enlarged choledochojejunostomy would result in a small duct being implanted into the jejunum with possibly subsequent stenosis at the anastomosis. Under these conditions I have implanted the normal bile duct into the jejunum and several centimeters distally performed cholecystojejunostomy. The method of implanting the common duct consisted of the insertion of silk sutures through the transected edges at opposite points the making of a stab wound into the jejunal lumen passing the two ends of the threads in the bile duct through the jejunal wall at points above and below the stab wound tying them in order to hold the bile duct tautly in the jejunum burying each knot by a serosal stitch and then inserting three or four serosal sutures to tighten the serosa about the common duct passing through the jejunal wall. In addition cholecystojejunostomy is performed with the same jejunal loop brought up for choledochojejunostomy. Thus two pathways are afforded for drainage of bile into the bowel.

SUMMARY OF RESULTS OF SURGICAL TREATMENT IN FIVE CASES OF
MALIGNANT TUMORS OF THE DUODENUM

Patient	Tumor	Operation	Result
Case I	Carcinoma second segment	Local resection of tumor and duodenal wall with adjacent pancreatic tissue Reimplantation of common bile and pancreatic ducts	Well 7 yrs 10 mos
Case II	Carcinoma first segment	Resection of upper third of duodenum pylorus and upper third of head of pancreas	Well 1 yr Died after second lap performed for recurrences
Case III			Well 3 yrs
Case IV	Round cell sarcoma involving most of duodenum	tomy Pancreatoduodenectomy	Died 7th day post operative
Case V	Carcinoma third segment	Pancreatoduodenectomy	Lived 3 mos Died of deep abdominal abscess that developed after discharge from hospital

COMMENT

Operations such as described above should, when possible, be carried out under continuous spinal anesthesia. At the onset of the operation, blood transfusion is started and continued as necessary to maintain a systolic blood pressure of at least 100 mm. of mercury.

The results of operative treatment in the five cases under discussion are summarized in the table.

General conclusions are not yet possible in regard to the surgery of primary malignant neoplasms of the duodenum. Pancreatoduodenectomy is the most radical procedure, but good results have been achieved with more conservative procedures. As in any surgical attack upon neoplasms each patient presents individual problems which must be evaluated if the surgeon is to carry out the best operation for that patient.

PRIMARY RESECTIONS OF THE COLON WITH SPECIAL REFERENCE TO SURGICAL DIAGNOSIS AND MANAGEMENT

KARL A MEYER, MD * AND DONALD D KOZOLL, MD †

THE decision as to the type of operation which can be performed on a patient with a surgical lesion of the colon and when it can be done, can usually be determined preoperatively by a consideration of the following questions

1. Where is the site of the lesion?
2. What is the nature of the lesion?
3. Is an obstruction present?
4. Is a protein deficiency present?
5. Is an anemia present?
6. Are there any complicating diseases?
7. How experienced a bowel surgeon is the operator?

1 SITE OF LESION

The localization of a lesion of the colon should commence in a logical sequence, starting at the anal end and working backward. Too often lesions are overlooked by depending upon roentgen examinations to identify lesions in the pelvic colon, an area which roentgenologists describe as being difficult for x ray identification. Another example of ill planned diagnostic procedures is the administration of oral barium before an obstructing lesion of the colon has been ruled out by barium enema, thereby precipitating a complete obstruction or producing a barium impaction with the necessity for a decompression operation. The order of events in the examination of the colon should be as follows

1. *Digital rectal examination including vaginal examination* in the female. A large majority of the lesions of the rectosigmoid are within reach of the index finger. A lesion within reach of the examining finger usually requires an abdominoperineal resection which will not be included in this discussion.
2. *Proctoscopic examination* should be performed next. Lesions within reach of the proctoscope are least apt to be visualized by x ray examination with the exception of an obstructing lesion.

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- 3 Biopsy of a lesion should be procured whenever possible, before undertaking a radical resection which necessitates a permanent colostomy. By this means an occasional error of mistaking an inflammatory or benign lesion for a malignancy can be prevented.
- 4 Barium enema should be next and can usually follow immediately after the proctoscopic examination because the colon will have been well cleansed.
- 5 Air contrast study following evacuation of the barium enema is the only method of identifying polyps above the sigmoid; this need only be done if all preceding measures have failed to reveal a lesion or if one wishes to rule out multiple polyps.
- 6 Barium meal studies should be the last item of the study and should not be attempted if there are any symptoms suggesting even a partial obstruction. Examples of patients requiring preliminary colostomy for a lesion which might otherwise be resected with a primary anastomosis because of the administration of barium by mouth, are still frequent.

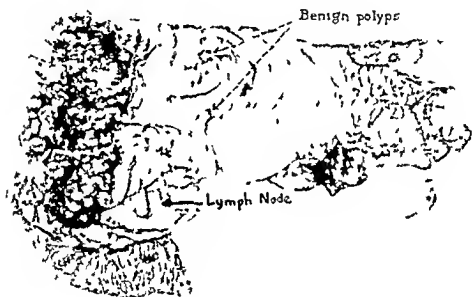


Fig 108—Specimen removed in Case I which includes terminal 12 inches of ileum and all of the colon down to the middle third of the transverse colon. This papillary type of carcinoma encircled the circumference of the cecum and encroached upon the ileocecal sphincter producing intermittent symptoms of obstruction. Note the gelatinous appearance of the lymph nodes which histologically was a metastatic colloid carcinoma.

Having identified the site of the lesion by the above procedures as outlined, the decision of the type of operation to plan and the patient's chances of surviving that operation can be influenced by a consideration of certain peculiarities inherent in the location of the lesion. These clinical observations have been described by Rankin, Barger and Bure.¹

The colon can be divided into two portions, right and left, from all points of view—anatomical, physiological, pathological and surgical. These fundamental differences can be best illustrated by specific cases.

Lesions of Right Half of Colon

CASE 1—Patient was a 66 year old white man who complained of a diarrhea for six months consisting of six to seven stools per day with passage of blood on rare occasions. During the same period he noted right lower quadrant pain which was frequently intermittent cramplike, and associated with tenderness and distention in that area. For three months prior to admission he was aware of a mass in the right lower quadrant the size of his fist which seemed larger and more tender during the episodes of cramplike pain. Physical examination revealed a marked pallor, a mass in the right lower quadrant the size of a large orange which

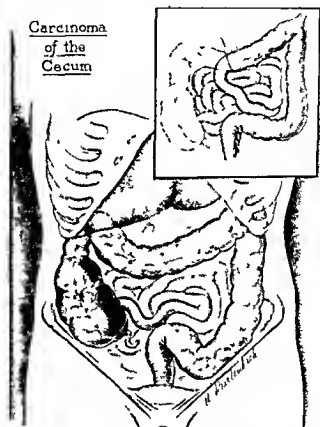


Fig. 109 Artist's drawings of the pathology *in situ* in Case 1 with the completed operation shown in the insert. An end to end ileotransverse colostomy was carried out by a technic described elsewhere.*

was firm and moved with respiration and a positive benzidine test for occult blood was obtained. Barium enema demonstrated a filling defect of the cecum.

The erythrocyte count on admission was 3 160 000, the hemoglobin was 49 per cent (Sahli) and the leukocyte count 5800. The total serum proteins were 5.84 gm, serum albumin 3.55 gm and nonprotein nitrogen 32 mg per 100 cc. The patient was placed on 12 gm of succinylsulfathiazole per day, ascorbic acid, brewers' yeast, an oral protein digest diet and 2000 cc of whole citrated blood was given in preparation for operation. The erythrocyte count was 5 500 000 and hemoglobin 90 percent after this preparation.

The pathological findings are shown in Figures 108 and 109 and the primary section with end-to-end ileocolostomy completed is shown in Figure 109.

CASE II—This patient was a 67 year old white woman who was admitted with complaints of belching after meals if she ate too much, distress after meals, anoxia, constipation, and cardiac consciousness. She had been taking 10 units of regular insulin every morning for the past several years, a panhysterectomy had been performed at the age of 42, and at the age of 65 she sustained a fractured vertebra from which she recovered.

Carcinoma
of
Hepatic
Flexure

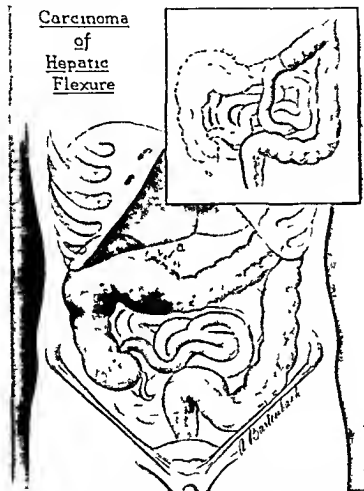


Fig 110—Artist's drawings of the laparotomy findings in Case II. Note the extension of the tumor to the greater curvature of the stomach (a) and the deformity of the colon it has produced. An end-to-end ileocolostomy was carried out in the same manner as Case I.

On entrance her blood pressure was 160/70, temperature 100° F, pulse 100 and respirations 20. She weighed 88 pounds, and had a marked pallor of all mucous membranes. A mass was present in the right upper quadrant, which measured 15x8 cm., was freely movable and not tender. On admission the erythrocyte count was 1,770,000, hemoglobin was 23 per cent (Sahli), and leukocyte count 15,500 with a differential smear showing 81 per cent polymorphonuclear leukocytes. The urine analysis was negative. Icces showed a positive reaction for occult blood and upon barium enema a carcinoma of the proximal one third of the transverse colon was demonstrated. On admission the nonprotein nitrogen was 30 mg per 100 cc,

total protein 5.9 gm per 100 cc with 3.4 gm albumin and a globulin of 2.5 gm. The patient's secondary anemia was corrected preoperatively by the administration of approximately 3100 cc of whole citrated blood (Table 3). Sulfasuxidine in 3 gm doses four times a day was given for one week preoperatively and enemas were given the day before operation. Levin tube suction was established before operation.

Under nupercaine spinal anesthesia a right paramedian incision was made and the lesion shown in Figure 110 was found. The tumor had extended into the gastrocolic omentum in the vicinity of the prepyloric area of the stomach and to the mesentery of the colon itself. Resection was undertaken and an end to end anas-



Fig 111 Barium enema study in Case III showing large filling defect of the splenic flexure and a calcified fibroid in the pelvis. Because of the size of the filling defect and the presence of nearby diverticulas the roentgenologist believed this lesion to be more likely an acute diverticulitis than a carcinoma.

tomosis completed between the terminal ileum and the distal transverse colon as shown in Figure 110. Interrupted catgut sutures were used as a first row and in interrupted silk sutures as a second row. The wound was closed in layers using fine interrupted silk sutures in the peritoneum, stainless steel in the fascia, and silk in the skin. Sulfanilamide was placed about the anastomosis and in the peritoneum.

The specimen measured 10.5 by 13.5 by 4 cm and consisted of a cauliflower ulcerating carcinoma of the hepatic flexure of the colon which had invaded all layers of the bowel wall. Histologically it conformed to the description of an infiltrating adenocarcinoma.

The patient had an excellent postoperative course. The maximal temperature during her entire convalescence was 100.6°F . She was given sodium sulfathiazole intravenously during the first three days she was on gastric suction with the Levin tube, thereafter sulfasuxidine was given. During her first postoperative week the urine output was maintained above 1000 cc daily, which we accept as the minimum. The patient was given protein postoperatively in the form of intravenous amino acids and oral protein with the results indicated in Table 4. She was discharged on her fourteenth postoperative day.

Summary—It will be noted that lesions of the right half of the colon are characteristically large in size, fungating, and metastasize rather late despite their size. Because the fecal stream is liquid, obstructive symptoms are exceptional. Severe secondary anemia is common. Resection with a primary ileocolostomy is the surgical procedure of choice.

Lesions of Left Half of Colon

CASE III—Patient was a 63 year old woman who knew she had a calcified uterine fibroid for thirteen years to which her symptoms of backache, anemia and weakness were attributed. She had planned to have a hysterectomy per-



Fig. 112—Photograph of surgical specimen removed from Case III. An annular stenosing and ulcerating adenocarcinoma of splenic flexure is present which measured 9 cm. in length and as much as 3.5 cm. in thickness.

med when she suddenly experienced an attack of abdominal pain of cramping character, distention but no vomiting. This persisted for one week and was relieved spontaneously. Before proceeding with the pelvic operation a barium enema study was done and the lesion shown in Figure 111 was identified. Because of the presence of diverticula and the size of the filling defect, the roentgenologist favored the diagnosis of an acute diverticulitis rather than carcinoma. The red blood count was 3,380,000, hemoglobin 64 per cent, and white blood

count 12,000. The urine was negative. The total protein was 5.65 gm and albumin 3.83 gm per 100 cc.

On admission to the hospital the patient was given a series of cleansing enemas and cathartics after which she was placed upon 3 gm of sulfasuxidine every four hours for six days. In the course of preparation for operation she was given 1000 cc of blood and 2000 cc of amugen after which her hemoglobin rose

to 10 g and a rectal tube

was inserted on the fifth day and three times a day thereafter.

The temperature was 100.6° F. Another transfusion of 1000 cc of blood was given postoperatively. The patient was discharged on the fifteenth postoperative day.



Fig. 113—Photograph of unopened specimen removed from Case IV to show the napkin ring constriction characteristic of lesions of the left half of the colon.

The tumor of the bowel was an ulcerating infiltrating adenocarcinoma which measured 9 cm in length, had encircled the entire lumen of the splenic flexure and measured

pressure was 200/130, temperature 99° F, pulse 80. A pelvic mass was palpated on bimanual examination but this was thought to be a uterine fibroid extrinsic to the rectum. A barium enema and flat plate revealed an obstructing lesion of the rectosigmoid. Because of failure to procure relief from enemas and increasing distention, an immediate transverse colostomy was performed.

She was studied further after relief from obstruction. Her total serum protein was 4.1 g per 100 cc, albumin 2.7 g per 100 cc, globulin 1.4 g per 100 cc, and anastomosis of the sigmoid colon was done by a technique described elsewhere. Her post-

operative course was uneventful and the transverse colostomy is to be closed as a third stage procedure. The lesion is shown in Figures 113 and 114.

Summary—Lesions of the left half of the colon are stenosing, ulcerating and infiltrating lesions which produce symptoms of bleeding, obstruction and altered bowel habit early. The procedure we favor

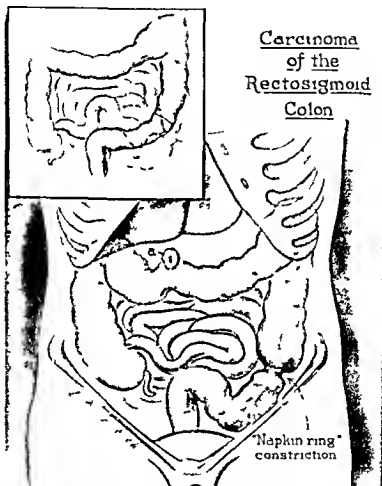


Fig 114—Art's drawing of the surgical findings and procedure in Case IV. An ovarian cyst the size of a grapefruit was removed before the rectosigmoid could be mobilized. A primary resection and open end-to-end anastomosis was performed as in Case III. The transverse colostomy (a) was closed at a later date.

for this segment is a primary resection and end to end anastomosis without a colostomy, in the absence of obstruction.

2 NATURE OF THE LESION

Although the majority of the lesions of the colon are malignant and require radical resection, it is important to recognize benign lesions when they occur and modify their treatment accordingly. To illustrate the importance of this possibility we present a case of a 6 year old child

CASE V—The patient was a 6 year old girl of Mexican descent, who entered the hospital on February 6, 1945, complaining of vomiting for one day and a right lower quadrant pain for two days. There were no previous episodes, diarrhea or fever. On February 9, 1945 the child was operated upon through a McBurney incision as an interval appendix case. The terminal 2 inches of the cecum were found to be thickened, inflamed, almost cartilaginous in consistency with an edematous serosa that was studded with many punctate areas of hemorrhage. The mesenteric lymph nodes were very much enlarged, one of these was removed for biopsy and nothing more was done. On histological section the lymph node showed a nonspecific hyperplasia.



Fig. 115—Barium enema study of Case V showing the marked contraction and filling deformity of the entire ascending colon which the roentgenologist recognized as a hyperplastic tuberculous.

for a possible tuberculous focus and negative Barium enemas on February 12, 1945. The roentgenologist recognized the marked narrowing and contraction of the ascending colon as a hyperplastic tuberculous. A barium enema given on June 12, 1945 (Fig. 116) showed a similar picture. The cecum and exploration was recognized as tuberculous of the cecum or a re-

commenced with the use of succinylsulfathiazole

The child was given 2 gm. of succinylsulfathiazole four times a day both as an outpatient and for three days preoperatively. Because of a normal blood count and good nutritional appearance she was given no preparation other than intravenous sodium sulfathiazole and enemas the day before surgery, a Levin tube

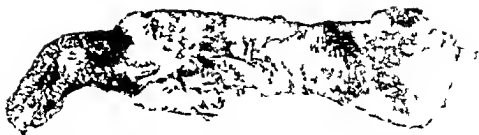


Fig 116—Photograph of the surgical specimen which includes terminal ileum shrunken ascending colon and proximal one third of the transverse colon. Mucosa is studded by many areas of hemorrhagic ulceration the mucosa is everywhere edematous and thickened and the submucosa was indurated. Marked regional lymphadenopathy was found. Histological sections revealed an ulcerative tuberculosis of the ascending colon.

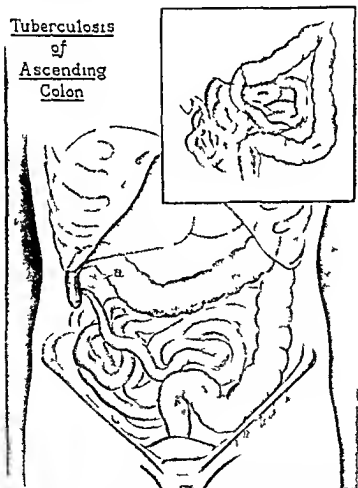


Fig 117.—Artist's drawings of findings at laparotomy in Case V. Note the shrunken ascending colon and marked regional lymphadenopathy (a). Insert shows the completed operation which consisted of a right hemicolectomy with ileo transverse colostomy.

was inserted before operation. She was operated upon on July 19, 1945 under ether anesthesia, a hemicolectomy with ileocolostomy being done (Figs 116 and 117). The specimen consisting of the terminal 6 inches of ileum with the right half of the colon down to the middle third of the transverse colon is shown in Figure 116. Histological sections showed an ulcerative tuberculosis of the ascending colon.

Postoperatively the child had an uneventful course. The Levin tube suction was continued for three days. She was given 500 cc of blood the day of the operation but none thereafter. She was given 3 gm of sodium sulfathiazole in 500 cc of saline solution for the first three postoperative days but as soon as the Levin suction was discontinued she was placed back on succinylsulfathiazole on the same dosage taken before operation. The patient was discharged on her twelfth postoperative day. Her maximal temperature during the entire postoperative period was 100.6° F.

In a previous paper² we reported two instances of primary resection of the sigmoid colon for a lipoma and a stercorous ulcer due to fecal impaction, fortunately these patients had a primary anastomosis performed without colostomy, for it would have been tragic to have left these patients with a permanent colostomy. In the identification of polyps of the sigmoid, a biopsy to rule out the malignant tendencies of these lesions is important before fulguration as the means of treatment is accepted.

3 OBSTRUCTING LESIONS

The presence of obstruction in lesions of the colon is a decisive factor in the treatment, management, mortality and morbidity. Wangensteen³ and others have clearly described the dangers in the depiction of colonic obstruction as a "closed-loop" obstruction between the ileocecal sphincter and the obstructing lesion. Because this loop cannot empty itself retrogradely, the increase in intraluminal pressure rises progressively to a point where perforation is an actual complication. In contrast, an obstructing lesion of the small bowel rarely causes perforation. In addition, the marked distention permits transudation of infected content and organisms through the colonic wall which is capable of producing a severe peritonitis. The pooling of venous blood and plasma like fluid in this long loop of obstructed gut is sufficient to explain the hemoconcentration which leads to shock and extrarenal azotemia. Clinical experience has further shown us that an obstructing lesion of the colon usually grows progressively more complete whereas a small bowel obstruction more frequently relents and will either spontaneously or in response to conservative measures release itself. The reason for this is probably that most obstructing lesions of the large bowel are carcinomatous in origin and such lesions usually cause progressively more stenosis, whereas, small bowel obstructions are frequently caused by a strangulated hernia, adhesive bands, or are paralytic in origin, and quite often decompress spontaneously. The need, therefore, in obstructing lesions of the colon is for immediate decompression.

The recognition of an obstruction of the colon can be made from the history and physical examination, results with enemata, flat plate of the abdomen, and a barium enema. A history of progressive distention, obstipation, intermittent pain, with or without vomiting in an aged individual usually makes the diagnosis quite obvious. Physical examination will usually add the features of a diffuse abdominal distention which is tense, usually nontender, and capable of loud borborygmi until the bowel becomes tonic. Digital rectal examination is not conclusive, for most lesions within reach of the examining finger do not obstruct. The administration of measured quantities of enemata



Fig 118—Appearance of wound one month after transverse colostomy for an obstructing lesion of the sigmoid colon. Note the clean, well-healed wound and absence of any excoriation. Stools are formed and it is usually unnecessary to divide the segments of colon to divert the fecal stream. Closure of this type of colostomy is simple and is enhanced by preparation with succinylsulfathiazole.

will yield helpful information if the returns are measured and their character noted. The patient will usually retain amounts of enemata in proportion to the distance between the anal sphincter and the obstructing lesion. Wangenstein recommends the use of the enema in conjunction with the x-ray, but we have often felt that the enema itself is capable of introducing air into the colon. Films of the abdomen taken in both the supine and erect positions will demonstrate both colonic distention and fluid levels which can usually be distinguished from small bowel distention. A barium enema carefully controlled with fluoroscopy will almost always demonstrate the obstruct-

ing site, but the procedure must be carried out with judgment, and the barium should be thinned out to permit easy expulsion

Decompression of obstructing lesions of the colon can be obtained only by colostomy. This should be performed as quickly, simply and with as little exploration as is possible. Most of these patients will be well advanced in years, are in very poor condition, and the time that would be required to appreciably improve their condition is fraught with the danger of complications. Attempts at exploration of the cause



Fig 119—X ray flat plate of the abdomen to demonstrate the inability of the Muller-Abbott tube to decompress obstructing lesions of the colon. This 76 year old male entered with an incomplete obstruction of the sigmoid but obstruction progressed despite introduction of the tube into the cecum (arrow). A transverse colostomy performed the same day under local anesthesia successfully relieved his obstruction, after which primary resection of his lesion and anastomosis were done. The colostomy was subsequently closed.

of obstruction are ill-planned, for they add to the postoperative mortality. These patients tolerate inhalant anesthetics poorly, therefore whenever possible local anesthesia should be chosen because of the reduced risk.

Transverse colostomy has been the colostomy of choice on our surgical service because of the simplicity and safety with which it can be performed by the resident surgical staff. The advantages are many. The mesentery of the transverse colon is far longer than that of the

ascending colon and exteriorization is therefore facilitated. The distention of the cecum and ascending colon is usually the most marked of all the portions of the colon, which makes the danger of tearing into its very thin bowel wall greater here than in the transverse colon. Because the majority of obstructing lesions of the colon originate in the left half of the colon, the transverse colostomy is just as effective in decompression proximal to the lesion as is a cecostomy. It is much easier to produce a constipated stool by diet with a transverse colostomy than with a cecostomy, which greatly improves the postoperative condition of the wound and the patient (Fig 118). In our experience cecostomies were more frequently associated with stricture of the stoma than transverse colostomies.

With the advent of the *Miller Abbott tube*, some speculation has arisen over the possibility that this might be a means of relieving the obstruction. Subsequent experience and a knowledge of the physiology of colonic obstruction have refuted this effort. Not only will valuable time be lost in the intensive efforts that are necessary to introduce this tube past the duodenum and advance it down the small bowel, but it will be opposed in passage by the ileocecal valve which is held firmly closed by the much greater intracolonic tension (Fig 119). Accordingly, we instruct our resident staff that such tube decompression has no place in the treatment of the large bowel obstruction. However, we do use an intragastric tube (Levin) to prevent the swallowing of more air and an increase in distention, but we do not delude ourselves in thinking that any tube is capable of decompressing the obstructed colon.

It is universally agreed that no resection should be attempted in the presence of acute obstruction. However, a primary resection and anastomosis can be safely performed from two to three weeks after the preliminary colostomy.

4 PROTEIN DEFICIENCY

In an earlier study⁴ we reported an incidence of protein deficiency in patients with malignant lesions of the colon of approximately 30 per cent, which exceeds the over all incidence for a large group of surgical lesions of 23 per cent. Rhoads and his associates⁵ noted a similar high incidence in this disease which after operation rose as high as 86 per cent. The explanation is not obvious because most of these patients are quite capable of eating, do not have protein deficient diets, and the lesion involves a segment of the gastrointestinal tract not primarily concerned in protein digestion and absorption. However, we have observed that patients with a severe diarrhea or melena lose as much as 20 gm of nitrogen in the stool in a period of twenty four hours which represents a loss of 125 gm of protein.

A large amount of literature has been developed concerning the significance of this protein depletion and a patient undergoing resec-

tion of the colon is just as apt to suffer as any other surgical patient with hypoproteinemia. To mention a few possible complications of contemplated surgery without correction of this deficiency one can anticipate nutritional edema, poor gastrointestinal motility progressing to the point of adynamic ileus, wound infection, wound evisceration, impaired wound healing, decubitus ulcers, loss of weight, anorexia, asthenia, pulmonary edema, and infections. In fact, in eighteen of thirty-four deaths on our surgical service a protein deficiency was present either before or after operation.

Recognition of this protein deficiency is not possible by laboratory methods alone. For although a total serum protein of less than 6.5 gm per 100 cc and of a serum albumin of less than 4.0 gm per 100 cc is definitely indicative of a protein deficiency, many of these patients will not show it because of coexisting dehydration or infection, both of which tend to falsely elevate circulating proteins. Accordingly, these protein values should be rechecked during the course of hydrating the patient and the hematocrit reading should be determined simultaneously as an index of the plasma volume. In clinical practice it is far better to assume that any patient who has lost weight as a result of a colon lesion, has had diarrhea, or melena, has a protein deficiency which should be rectified in the course of treatment.

Management.—There are several means of dealing with the protein deficiency state, depending upon the particular needs and condition of the patient: oral protein feedings, parenteral amino acids, plasma infusions, and blood transfusions. Each of these methods has its advantages and disadvantages.

Oral Protein Feedings.—The correction of a protein deficiency by oral route presupposes that the patient is capable of ingesting rather large quantities of food by mouth. The minimal quantity of oral protein that will repair preexisting losses is in the neighborhood of 100 gm per day, and the more the patient can ingest the more rapid will be his gain. To provide an oral intake of 100 gm of protein per day in the average diet is an ambitious program because it requires considerable bulk. For example, a quart of milk contains only 35 gm of protein, and $\frac{1}{4}$ pound of steak yields approximately 25 gm of protein. Until lately the administration of significant quantities of amino acids was a difficult undertaking because of its objectionable taste, but recently a palatable oral protein digest was made available to us for study. Table 1 represents efforts at preparing patients with lesions of the colon for surgery employing this oral protein as the exclusive source of nitrogen. In another report, in which these cases will be included, examples of administration of as much as 300 gm of a protein digest per day by mouth will be reported. The advantages of this method are that the patient can ingest larger amounts of nitrogen by mouth than it would be possible to inject by vein, because the rate of excretion for oral administration is less than with intravenous injection.

TABLE 1—ATTEMPTS AT CORRECTION OF A PROTEIN DEFICIENCY IN A PATIENT WITH A TRANSVERSE COLOSTOMY FOR AN OBSTRUCTING LESION OF THE SIGMOID COLON WHICH SUBSEQUENTLY PROVED INOPERABLE*

Oral Protein† per Day, Gm	No of Days	Plasma Volume, Cc	Total Protein, Gm per 100 Cc	Total Circulating Protein, Gm	Albumin, Gm per 100 Cc	Hemato-crit, Per Cent
60	3	2857	5.31	151	3.50	46
90	5	2764	5.60	155	3.51	45
155	4					
220	4	3175	5.54	176	3.35	42

* Note that on doses of 60 to 90 gm of protein relatively slight improvement has occurred although nitrogen balance (which will constitute a separate report) was attained in the total

TABLE 2—PROTEIN DEFICIENCY OCCURRING POSTOPERATIVELY FOLLOWING AN ABDOMINOPERINEAL RESECTION IN A SIXTY-FOUR YEAR OLD WHITE MAN*

Date	Intravenous Amino Acids,† Gm	Total Serum Protein, Gm per 100 Cc	Serum Albumin Gm per 100 Cc	Hematocrit, Per Cent
6/26	90	5.86	3.09	30
6/27	90	6.01	3.11	32
6/28	90	6.19	3.15	33
6/29	90	6.53	3.37	30
6/30	90	6.35	3.30	30
7/1	90			
7/3	90	6.54	3.38	28
7/5	90	6.39	3.42	25
7/6	90	6.61	3.53	28

* Patient had a nitrogen balance of 1.1 gm N retained per day.† 20% solution of amino acids.

there is more retention of nitrogen. The necessity for preparing pyrogen-free protein for intravenous use is eliminated, and the cost of this form of protein therapy should be much less than with parenteral feeding programs. We have employed intragastric feedings of amino acids using a Levin tube, but on none of the patients included in this report

Parenteral Amino Acids—Since Elman⁶ demonstrated the possibility of administering amino acid digests for parenteral protein nutrition, this method has gained popularity both to supplement that which can be taken by mouth and to supplant oral feeding, when the latter is unfeasible as it frequently is during surgery. Table 2 is an example of a patient developing a protein deficiency after an abdominoperineal resection. This was corrected by a preparation of intravenous amino acids which we have previously reported⁷ as capable of producing positive nitrogen balance. The disadvantages of an exclusively intravenous regimen of protein nutrition are that it is difficult to insure an adequate caloric intake to protect the amino acids from breakdown to a carbohydrate, that the amount of amino acids which can be given intravenously is limited (less than the oral route), this route of administration is frequently handicapped by inadequate veins, minimal side reactions such as local thrombosis of veins, nausea and emesis which occur often enough to be of some concern, and the cost of intravenous amino acids to the private patient is still prohibitive if it is required in large amounts for prolonged intervals. Notwithstanding all these objections, the availability of this route of protein administration when other routes are impracticable can often be life-saving.

Plasma Infusions—The use of plasma as a source of protein nutrition has been long recommended, but subsequent experiences have indicated that it, too, has its shortcomings. To elevate the circulating plasma proteins 1 gram per 100 cc would require an estimated 2000 cc of plasma. Mulholland and his co-workers⁸ ventured the opinion that to achieve nitrogen balance with plasma in a seriously ill patient, would require the plasma of 26 pints of blood donated each day. With dried plasma costing a private patient \$35.00 for 250 cc, the reliance upon plasma to achieve correct protein levels would be prohibitive in most cases. In our own experience, we have found plasma to be quite ineffective in elevating plasma protein levels.⁴

Whole Blood Transfusions—We have found the use of whole blood transfusions, especially in conjunction with amino acids, to be the most effective and rapid means of improving the circulating proteins (Tables 3 and 4). It is to be remembered that in the administration of a pint of blood one not only gives 18 gm of plasma protein that is customarily given in the plasma infusion, but in addition 75 gm of hemoglobin. Whipple and his co-workers⁹ have demonstrated that hypoproteinemic dogs were capable of synthesizing plasma protein from hemoglobin. In our earlier work⁴ we have shown that not until one gives 2000 cc or more of blood does he produce consistent improvement in the protein concentration or hematocrit reading. Accordingly, we have taught our staff that each of our adult patients coming to operation should arbitrarily have received a minimum of 2000 cc of whole blood, unless they have been prepared by some other special means such as oral or intravenous amino acids. It is not

unusual for us to administer as much as 10,000 cc of whole blood in the course of an illness such as ulcerative colitis requiring total colectomy.

TABLE 3—INFLUENCE OF BLOOD TRANSFUSIONS IN THE CORRECTION OF A SEVERE SECONDARY ANEMIA OF A PATIENT WITH A CARCINOMA OF THE HEPATIC FLEXURE OF THE COLON*

Date	Amount of Whole Blood, Cc	Red Blood Cells	Hemoglobin Per Cent
7/6		1 770 000	23
7/18	500		
7/19	500		
7/20	500		
7/21	100 (reaction)		
7/23		3,550 000	58
7/26	1000		
7/27	500		
7/28		4,110 000	78

* This 88 pound patient received 3100 cc of blood prior to surgery with a restoration of her blood picture as shown. Postoperatively she was treated with amino acids intravenously and orally as shown in Table 4.

TABLE 4—POSTOPERATIVE PROTEIN THERAPY REGIMEN IN A SIXTY-SEVEN YEAR OLD WOMAN WEIGHING EIGHTY-EIGHT POUNDS, WITH A CARCINOMA OF THE HEPATIC FLEXURE FOR WHICH A HEMICOLECTOMY AND ILEOTRANSVERSE COLOSTOMY WAS DONE*

Date	Intravenous Amino Acids†	Oral Protein, ‡ Gm	Plasma Volume, Cc	Total Protein, Gm per 100 Cc	Total Circulating Protein, Gm	Albumin, Gm per 100 Cc	Hematocrit, Per Cent
7/28	500 cc blood		2011	5.80	116.6	3.10	44
7/29	30 Gm						
7/30	75 Gm						
7/31	60 Gm	20					
8/1	90 Gm	35					
8/2	90 Gm		2040	5.43	110.7	2.95	43

* A fall in total proteins of 0.37 gm per 100 cc following surgery (or a loss of total circulating protein of 5.9 gm) is minimal and less than we have previously found to be significant. A comparison of the proteins administered and the proteins ad

5 ANEMIA

The presence of anemia in a patient with a lesion of the colon has both diagnostic and therapeutic significance. Although the frequency of marked secondary anemia in patients with lesions of the ascending colon is generally appreciated, the causative factors are less well under-

stood. Most authors agree that not all of the anemia can be attributed to blood loss, for certainly blood loss is as great from lesions from the left half of the colon where bleeding is more typical and occurs earlier. Other factors which have been discussed from time to time as related to this anemia have been the nutritional deficiencies of these patients, the disturbed absorption of iron which is supposed to take place in the right half of the colon, and other less well understood toxic and hepatic factors.

Although the recognition of the severe anemia that goes with lesions of the ascending colon is seldom difficult (we have recently had a patient with a carcinoma of the cecum with an erythrocyte count of 900,000 per cubic centimeter and a hemoglobin value of 13 per cent) the anemias of less degree are frequently overlooked because of the hemoconcentration that may result from a diarrhea of long standing. Accordingly, erythrocyte counts should be checked after therapy has been instituted. We have been impressed with the greater accuracy of the hematocrit over the erythrocyte count in the average technician's hands. Further, because the hematocrit is performed upon venous blood, and the red count upon capillary blood, the former is less apt to be influenced by such phenomena as vasoconstriction and vasodilatation.

A variety of measures are at hand to correct the anemia of colonic disease, and in the case of the right half of the colon probably all should be combined. A *high protein diet* will contribute its benefits in the proper direction, for the body uses amino acids for building hemoglobin just as it does for any cell. Because the anemia is usually iron deficiency in type, the use of *iron salts* is of value but many months would be required to correct the loss by this means alone. The use of *liver extract* has been encouraged by some in the belief that some hepatotoxic factor is in part operative, although this adjunct is admittedly empirical. The use of *red cell suspensions* would correct the anemia more rapidly than by any other means, for one flask of such washed cells frequently contain as much as 150 gm. of hemoglobin. At present it is probably the least expensive method of correcting such a severe anemia for through the cooperation of the Red Cross Blood Banks, such cells are now available at a nominal charge of \$5.00 for each flask. However, because these patients require not only an improvement in hemoglobin stores but protein stores as well, we feel that *whole blood transfusions* will still serve both purposes at the same time, and accordingly use whole blood in rather large quantities (Table 3).

6. COMPLICATING DISEASES

The patient with a lesion of the colon will have certain accompanying diseases which are attributable to his age and the effect of his disease upon his body economy. However, these diseases demand that

we defer treatment long enough to recognize them and treat them appropriately lest our best efforts be frustrated. Hypertension, arteriosclerotic heart disease, nephrosclerosis and chronic bronchitis are typical of any group of patients in the age group in which lesions of the colon are usually seen, and their incidence here is not disproportionate. Nevertheless, it bids one to be on guard against cardiac accidents, pulmonary edema, renal failure and pneumonia.

Patients with obstructing lesions of the colon not infrequently enter the hospital in such a severe state of dehydration that renal function is diminished to a point which produces nitrogen retention which at times is indistinguishable clinically from uremia, however the response to dehydration is so dramatic that the basis for the nitrogen retention soon becomes evident. Such dehydrated patients are more susceptible to parotitis and measures to promote local oral hygiene and parenteral fluids are both in order. The senile patient is more apt to show evidence of oral sepsis and unless this is recognized the patient may eventually be lost due to a lung abscess aspiration pneumonia or endocarditis. A remaining complication that merits definite efforts in recognition is urinary retention due to a hypertrophied prostate. In view of the high frequency of urinary complications following colon surgery, everything should be done to minimize this complication even if it necessitates a prostatic resection before the bowel resection.

EXPERIENCE OF THE OPERATOR

We have previously reported, as have others our partiality for primary resection of lesions of the colon with immediate anastomosis. In the case of lesions of the left half of the colon we have done this without complementary colostomy. At the time of the previous report we had included twenty patients from the private practice of one of us (Karl A. Meyer) with one death, since that report we have operated upon five more private patients with lesions of the left half of the colon and were able to carry out a primary resection, anastomosis without colostomy, without any further deaths. This makes the overall mortality for the twenty-five patients 4 per cent.

The reasons why we think we are able to get the results we have with this rather recent approach have been discussed in full detail in the article alluded to. We feel it is related entirely to the preoperative and postoperative care, the fundamentals of which we shall list presently. The trend for primary anastomoses has been applied to ampullary lesions of the rectum by Wangenstein¹⁰ although the adequacy of this procedure in removing perirectal lymphatic tissue has been questioned.

The results achieved with primary resection are the result of extensive experience and teamwork and the occasional operator can hardly expect to achieve the same success. Undoubtedly it would be better for the surgeon who performs a limited number of bowel resections

per year to favor exteriorization operations such as described by Lahey (ileocolostomy) and by Mikulicz and Rankin for lesions of the left half of the colon. Although these procedures have the disadvantages of multiple stage operations, they are safer in the hands of the infrequent operator.

PREOPERATIVE ORDERS

In another paper on this subject and in the preceding pages we have discussed at some length the physiological principles underlying our plan of preparation of these patients for surgery, we will therefore only list the routine measures as we have standardized them on our surgical service.

- 1 *Diet* To include 100 gm or more of protein and 500 gm or more of carbohydrate in the form of low residue foods. Six feedings per day will facilitate adequate caloric intake.
- 2 *Succinylsulfathiazole* Three grams every four to six hours night and day given for a minimum of one week.
- 3 *Blood Transfusions* A minimum of 2000 cc of blood is given to all patients in whom a resection is contemplated.
- 4 *Parenteral Amino Acids* Sixty to 100 gm per day to all patients with protein deficiency or unable to eat.
- 5 *Vitamins*, oral or parenteral per day

Ascorbic Acid	300 to 500 mg
Thiamine Hydrochloride	50 mg
Riboflavin	3 mg
Pantothenic Acid	6 mg
Niacin	150 mg
- 6 *Paragoric* (1 drachm for two doses) or *Powdered Opium* ($\frac{1}{4}$ grain for two doses) is given the afternoon and evening before operation to control persistalsis.
- 7 *Enemas* Cleansing enemas are given the day before surgery. They are not given earlier in order not to decrease the effect of the sulfasuxidine. They are not given closer than twelve hours before surgery to prevent the retention of enema fluid within the colon and subsequent spillage at operation.
- 8 *Levin Tube* All patients coming to operation for a bowel resection have an indwelling gastric tube to prevent aspiration and postoperative distention.
- 9 *Preadesthetic Medication* A barbiturate is administered the night before operation to insure a good night's rest. Morphine is given one hour before operation in smaller doses for spinal anesthesia than for an inhalant anesthetic is administered in customary quantities.

OPERATIVE PRINCIPLES

We have previously reviewed the arguments pro and con in reference to the procedure we have elected to follow. Here we shall only reiterate the fundamental principles involved.

Wherever possible we have employed spinal anesthesia most often with nupercaine.¹¹ This anesthetic has provided an adequate period of anesthesia without the necessity for an indwelling spinal needle. The muscular relaxation and quiescence of the intestinal loops under spinal anesthesia have been a definite advantage. Those patients who required

an inhalant anesthetic showed a higher incidence of postoperative pulmonary complications

We have employed the method of "open" resection quite freely and have found it far simpler and less cumbersome than the "closed" methods requiring a variety of clamps. We have not had a single instance of a death due to peritonitis in our cases. We attribute this record to employment of succinylsulfathiazole preoperatively, the use of sulfonamides locally, and of sulfadiazine intravenously.

All of our anastomoses were performed end to end and with the use of interrupted sutures. Fine chromic catgut sutures on atraumatic needles were employed in the mucosa, silk or wire sutures on similar needles were placed as a second seromuscular row. The rent created in the mesentery is also closed with interrupted sutures. The security of the use of interrupted sutures cannot be questioned but of additional importance is the fact that such sutures do not encroach upon the lumen. In the case of ileocolostomy (Cases I, II, V) we have been able to employ an end-to-end anastomosis as well, to insure an adequate ileal stoma we have either divided the ileum diagonally or cut the bowel wall of the ileum for a short distance on its antimesenteric surface.

All wounds have been closed with interrupted sutures using silk in the peritoneum, 32 gauge stainless steel wire in the fascia and silk in the skin. This method of closure has enabled us to get our patients out of bed starting with the first postoperative day and increasing the period of ambulation each day. We have had no instance of wound evisceration and the number of wound infections has been minimal.

POSTOPERATIVE ORDERS

We shall only summarize our standard postoperative routine, the basis for which has been previously discussed.

- 1 *Parenteral Fluids* A basic quantity of 3000 cc. of fluids per day is administered which will be increased if there is an undue loss from suction, perspiration or drainage or if the patient excretes less than 1000 cc. of urine per day. In senile or cardiac patients this fluid may be given subcutaneously, otherwise it is given intravenously at less than 60 drops per minute. Not more than 1000 cc. is saline unless indicated.
- 2 *Transfusions* These are rarely necessary postoperatively if the patient has received 2000 cc. or more preoperatively. However we do not hesitate to give unlimited quantities as is deemed necessary.
- 3 *Gastric Suction* The Levin tube inserted before operation is attached to a Wangenstein suction apparatus and continuous suction applied. All siphonage material is collected and if it exceeds the quantity taken in the form of drink or irrigation, it is calculated in the patient's saline requirement. Suction is continued until peristalsis returns and this is usually on the third postoperative day.
- 4 *Hyperventilation* It is employed routinely using mixtures of carbon dioxide and oxygen. We recommend its use every one or two hours and kept up until hyperpnea occurs or the patient coughs.

- 5 *Oxygen* In patients whose condition is precarious or have a cardiac complication it is used routinely either with a nasal catheter or B.L.B. mask. Although 100 per cent oxygen has acknowledged value in the treatment of distention we have not resorted to its routine use for that purpose relying upon the Levin tube instead.
- 6 *Intravenous Sulfonamides* For the first three postoperative days while the patient is on gastric suction the sulfonamides are administered by this route thereafter succinylsulfathiazole is administered orally. To insure the excretion of the acetylated sulfa drugs we have frequently used a liter of N/6 molar lactate to alkalinize the urine.¹² We attempt to maintain a blood sulfa level during the immediate postoperative period of between 8 and 12 mg per 100 cc.
- 7 *Elevation of the foot of the bed* is employed during the first twenty four hours to prevent shock and to encourage the drainage of mucus from the respiratory tract.
- 8 *Fluids per os* are given immediately postoperatively so long as the inlying gastric tube functions. This promotes oral hygiene prevents a parotitis and makes the Levin tube more tolerable. Lemon juice encourages salivation.
- 9 *Morphine* or other opiate is used postoperatively in quantities sufficient to control discomfort.
- 10 *Catheterization* of the bladder is employed routinely if the patient has not voided by the conclusion of the day's parenteral fluids for the bladder is most apt to be full then. An inlying catheter has only been used in incontinent patients to prevent skin maceration and decubitus ulcers.
- 11 *Diet* This is usually started by the fourth postoperative day and commences with boiled fruit juices in quantities of 2 ounces every hour. This progressively increases in quantity and variety to a low residue diet. The patient eats a regular diet at home.
- 12 *Intamins* These are given in the same dosage as preoperatively. They are given intravenously while the patient is on intravenous fluids; thereafter they are given orally.
- 13 *Enemas* These are not administered until the fifth or sixth postoperative day and then in small amounts. Most patients have a spontaneous stool by this time and enemas are unnecessary.
- 14 *Ambulation* Patients are placed in a wheel chair for fifteen minutes on the first postoperative day and for increasing lengths of time each day subsequently so that they are walking alone by the sixth or seventh postoperative day.
- 15 *Parenteral Amino Acids* are used postoperatively where indicated in the same manner as in the preoperative period.

CONCLUSIONS

A plan of management of lesions of the colon is presented which emphasizes an orderly sequence of events in diagnosis, standardized preoperative and postoperative regimen and an operative technique which in our hands has resulted in a mortality rate of 4 per cent and a minimal morbidity rate.

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TECHNICAL DETAILS IN THE MANAGEMENT OF THE DUODENUM IN GASTRIC RESECTION

RAYMOND W McNEALY, M D *

In a previous article I called attention to some of the problems which are met in the management of the stump of the duodenum during the course of a gastric resection. What I have seen and heard since then encourages me to review many things which were presented in detail at that time and to add some suggestions which were omitted in the previous paper.

While some of the steps which will be discussed are very familiar and admit of minor variations, it will serve a useful purpose if a detailed account is given of the handling of the duodenal stump in an uncomplicated partial gastric resection for ulcer.

On opening the peritoneal cavity a thorough survey of the entire contents is made, the lesion for which the resection is being done is carefully examined and the stomach and duodenum are carefully explored for fixation, edema and lymph nodes.

In beginning the resection the usual procedure is to break through the avascular area of the gastrohepatic omentum medial to the left gastric artery and medial to the right gastric artery. One is now able to pass the index and middle fingers into the lesser peritoneal cavity and by a sweeping motion to free it from the peritoneum overlying the pancreas. It is now rather easy to push the middle finger down and medialward where it will stand out below the greater curvature near the pyloric vessels. With a curved forceps the gastrocolic omentum can be torn through at this point without causing any bleeding. The middle finger can then be pushed through this opening and a cotton tape passed from greater curvature to lesser curvature behind the pyloric end of the stomach. This sling tape aids greatly in steadying the organ for further manipulations (Fig. 121, A and B). The greater curvature is now freed of its gastrocolic attachment, passing along the greater curvature toward the fundus of the stomach. When it has been freed toward the fundus it is then a favorable time to ligate all vessels and remove all forceps attached before proceeding toward the pyloric end of the stomach. I have found it very helpful to proceed carefully to the region of the division of the gastroduodenal artery and then again ligate all vessels and remove clamps. At this juncture the lesser curvature is approached and the varying right gastric artery is ligated by a suture ligature. This must be done carefully under sight.

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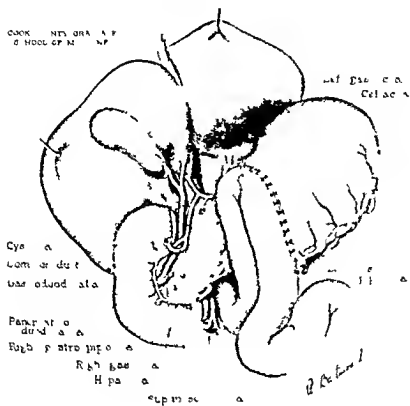


Fig 120—Arterial supply of gastroduodenal region

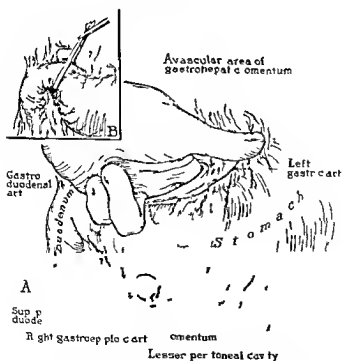


Fig 121—A The middle finger is pushed through the opening and a sling tape B is applied

to be sure that the common duct is not encroached upon. With both the lesser curvature and the greater curvature freed up to this point it now becomes necessary to divide the attachment of the pancreatic capsule and its peritoneal covering to the posterior aspect of the duodenum just beyond the pylorus. This step must be done with caution because it is easy to invade the gastroduodenal artery and cause unnecessary bleeding. The common duct may also be encroached upon if the dissection is not carefully done. The greatest danger is found in those duodenal ulcers which penetrate the posterior wall of the duo-

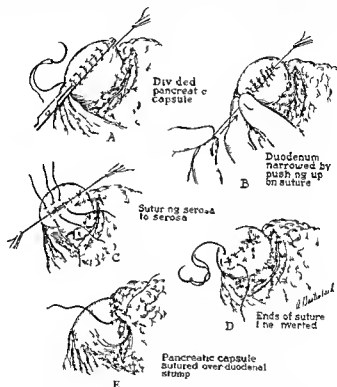


Fig. 122—Steps in the operation (For explanation see text)

denum near the superior convexity of the first portion of the duodenum.

When the pancreatic capsule is divided as shown in Figure 122, *A* the duodenum is clamped on the stomach side with a crushing holding clamp and a lighter clamp applied to the duodenum itself. When the duodenum is divided and the stomach turned back, attention is turned to closure of the duodenal stump. Many papers have stressed the importance of a secure closure of this part of the duodenum and the importance of this step merits the space devoted to it. For several years I have used a very simple method of closure. It is secure and takes very little time. A single fine silk suture is used in a running stitch over the

holding forceps as shown in Figure 122, *A*. When the forceps is removed the duodenum is slid along the suture and the duodenum is much narrowed (Fig. 122, *B*). The second row of sutures is interrupted and brings serosa to serosa over the first line (Fig. 122, *C*). Care is used in seeing that the ends are not left dog eared but well inverted as in Figure 122, *D*. The third row is a little less closely spaced than the second row and serves to bring the pancreatic peritoneum and capsules over the line of suture just made and fix the capsule to the anterior surface of the duodenum just beyond the second suture line as shown in Figure 122, *E*.

Complications—There are a number of complications which center about the closed blind ended duodenal stump. Most of these can be prevented if careful attention is given to the details of management which have been presented from time to time. In or about the closed duodenal stump the following complications may occur.

In the immediate postoperative period or later, a serious *hemorrhage* may occur. It more frequently has its origin from an eroded vessel in the wall or depth of an unsectored ulcer. Less frequently it results from injury to or leakage from an insecurely ligated vessel in the region of the closed duodenum. The gastroduodenal artery or one of its branches is usually at fault. If the bleeding is from the ulcer area it flows into the duodenum and may be vomited or passed in the stool. If the vessel is not in the ulcer, the bleeding usually occurs into the peritoneal cavity and may not easily be diagnosed.

Various degrees of *leakage* from the closed stump of the duodenum may occur. If it is small in amount and slow in appearance there may be sufficient walling off by the viscera and omentum to form a localized *abscess*. In other instances there may be a complete or *frank disruption* of the closed stump with diffuse soiling of the peritoneum. In the case of abscess formation or disruption of the sutured duodenum there not uncommonly follows an escape of the exudate to the surface through the original incision in the abdomen. A *duodenal fistula* may make its appearance after this and lead to endless suffering from uncontrollable erosion of the skin and tissues about the site of the fistula. The management of these fistulas requires patience and ingenuity and the morbidity and mortality in these patients are very high.

RESECTION OF ULCER IN THE DUODENUM

When a partial gastric resection for duodenal ulcer is decided upon the implication is that enough stomach will be resected to insure against continued excessive acidity of the gastric secretion. In addition it is presumed that the ulcer in the duodenum will also be resected. There is little excuse for not doing this in some instances but there are many times when resection of the ulcer in the duodenum assumes heroic proportions. The two complications which lead most frequently to partial gastric resection are hemorrhage from vessels eroded

by the ulcer or pyloric stenosis from inflammatory infiltration, edema and scar formation. The proximity of the gastroduodenal artery and common duct is illustrated in Figure 123, A.

When the ulcer is on the anterior wall of the duodenum, close to the pyloric vein, closure of the stump presents comparatively few difficulties. In some instances the scarring may be so marked that identification of the exact limits of the pylorus and duodenum may be uncertain. In these patients it may be difficult to apply a clamp to the duodenum in a manner which will allow of its inversion by the usual method. In these, it is probably safer to apply a clamp to the stomach side and support the cut end of the duodenum with Allis' forceps. If there is any doubt about the presence of the gastric ring mucosa of the pyloric end of the stomach, the mucosa may be cut away for a distance of a centimeter or more. The duodenal stump is closed with either interrupted silk sutures or a single running suture of catgut reinforced by two rows of interrupted nonabsorbable sutures of silk or cotton. The second row of nonabsorbable sutures approximates the peritoneum of the pancreatic capsule to the anterior surface of the closed duodenum.

More than 60 per cent of duodenal ulcers are on the posterior wall. It is in this location that it is most likely to be complicated by massive hemorrhage or by pyloric stenosis. These complications, hemorrhage and stenosis, are the most common imperative indications for surgery. If the operation is done for single large hemorrhage or recurrent bleeding, there arises the necessity of preventing any further bleeding from the eroded vessel. As mentioned before, this bleeding vessel is usually found to be the gastroduodenal artery or one of its smaller divisions located in the ulcer crater and surrounded by pancreatic tissue (Fig. 123, B). Not infrequently the ulcer area infringes on the gastroduodenal ligament and causes it to be infiltrated and edematous. In many of these patients it is a real chore to bring them up to a level where they are even fair risks for so serious an operation as gastric resection. Even when they are in good condition, their safety margin may be alarmingly narrowed by injudicious handling of the duodenum and its penetrating posterior wall ulcer. There are several ways of attacking this problem and no fixed rule can be laid down for each case in advance.

If the operation is done for pyloric stenosis, the obstructed area may be so infiltrated and edematous that it is impossible to follow lines of cleavage or accurately identify the anatomical structures in the vicinity. If an attempt is made to free the superior flexure of the duodenum from the pancreas and carry the dissection beyond the ulcer, it will be very difficult to follow the duodenal wall because of its friable condition and its intimate adherence to the surrounding structures. Bleeding from many small vessels is usually troublesome and tends to obscure further the pursuit of duodenal mobilization.

The gastroduodenal artery is embedded in the pancreas just behind the first portion of the duodenum and it offers many obstacles to free dissection of this area. If an attempt is made to isolate and ligate the gastroduodenal artery above the superior flexure of the duodenum as a means of controlling hemorrhage in the ulcer depth or from the pancreatic bed of the duodenum, the result will usually be disappointing. It will be necessary, as a rule, to ligate also the vessel below the duodenum where it branches into the pancreatic and epiploic divisions

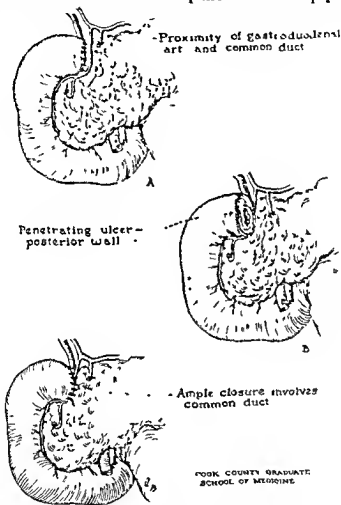


Fig. 123 (For explanation, see text.)

Accurate ligation both above and below the duodenum will usually insure against further extensive hemorrhage, but the rich collateral bed of the gastroduodenal artery leaves this method somewhat questionable. Direct suture of the eroded vessel in the ulcer bed is most unreliable because of the extremely friable condition of the vessel and its surrounding tissue.

Even if one were successful in freeing up the duodenum, there still remains the problem of mobilizing enough wall for an inversion which would be adequate to prevent leakage or disruption.

It is the gastroduodenal artery that is most obtrusive in dissection of the duodenum, but the presence of the common bile duct just distal to the artery presents an additional hazard. In pursuing an attempt to close adequately the duodenal stump, several cases have occurred in which the common duct has been completely obstructed (Fig 123, C). This is a most unfortunate accident, for the dissection necessary for release and repair is also very difficult. The fact that a mild transitory jaundice, due to angulation or temporary compression of the common duct, not infrequently appears following a gastric resection and clears

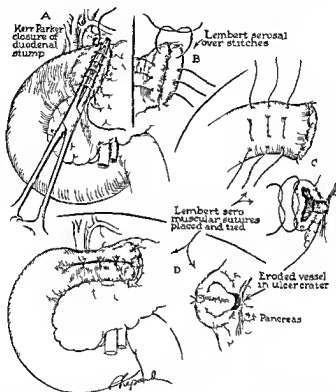


Fig 124—Method of closure of duodenal stump (For explanation, see text)

up after a few days, is undoubtedly responsible for unwarranted delay in the cases where the common duct is completely obstructed during the duodenal stump closure. In the hope that each case of postoperative icterus may be of the temporary type, further surgery is not attempted until the condition has shown no tendency to improve spontaneously and the patient becomes progressively more deeply jaundiced.

From what has been said it is obvious that the vulnerable posterior wall of the duodenum is one of the principal hazards in gastric resection.

In my experience the necessity for resecting the duodenal ulcer area does not seem to be at all imperative. There is a tendency for these ulcers to heal as soon as the gastric secretion is completely diverted. Where bleeding has been present before surgery and exploration reveals a penetrating ulcer of the posterior wall in the first portion of the duodenum, I have found very useful a method of closure which has been termed "closure of the duodenum with tamponade." It is developed along the following lines:

The duodenum is divided between clamps at or near the pyloric orifice. The duodenum is freed up cautiously so as not to invade the ulcer area on the posterior wall. After preliminary closure of the stump with a Kerr-Parker stitch, or more commonly, a simple over-and-over suture (Fig. 124, *A* and *B*), the duodenum is then plicated longitudinally for a distance of 1 to 1½ inches (Fig. 124, *C* and *D*). This plication extends beyond the ulcer crater of the posterior wall. The purpose of the plication is to crowd the anterior free wall down into the penetrating ulcer crater on the posterior wall, as shown in the diagrammatic cross section of Figure 124, *D*. In many ways this procedure follows the principles of the obliterative aneurysmorrhaphy of Matas. The enfolding not only tamponades the ulcer from which the hemorrhage, if any, has come but it also protects the weak stump from leakage and disruption. Fogelson and his co-workers have shown that this method adds greatly to the security against blowouts of the duodenal stump.

INTRALUMINAL PRESSURE IN THE DUODENAL STUMP

When a gastric resection has been done and the gastrojejunal anastomosis completed, the gastric contents escape directly into the jejunum and only a small portion should find its way into the duodenum. There is, however, the normal duodenal content of bile, pancreatic juice and secretions of duodenal mucosa which should be in the neighborhood of 1000 to 1500 cc. in twenty-four hours. With this quantity of fluid pouring into the short duodenal loop, it is easy to understand how any interference to the outflow of this proximally closed loop would lead to distention and dangerous intraluminal pressure. The effects of retention and distention of this duodenal loop have been emphasized by many writers.

Several complications have been shown to contribute to obstruction to the duodenal outflow following gastric resection. The three most commonly found are: (1) the jejunum is acutely angulated from improper fixation at either the greater or lesser curvature angles of the anastomosis; (2) obstruction may result from constriction of the afferent or efferent loops of the anastomosis by the mesocolon through which the anastomosis must pass; (3) herniation of the jejunum may occur and much of the small intestine slip into the lesser peritoneal cavity.

Many authors have stressed the importance of careful suture of the angles of the anastomosis because they do not lend themselves easily to accurate closure. Finsterer suggested a method of reinforcing the lesser curvature angle by a half purse string suture of the stomach and adjacent jejunum. If correctly applied no difficulty arises, but if the jejunum is angulated too acutely along the lesser curvature a defi-

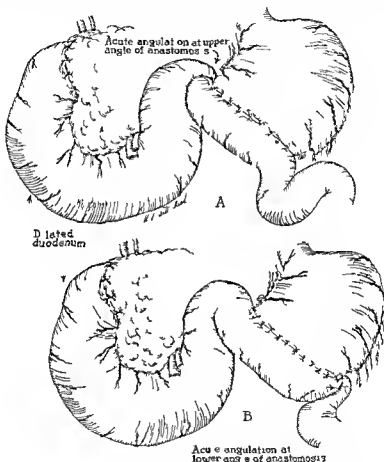


Fig. 125—Acute angulation at (A) upper and (B) lower angles of anastomosis

nite obstruction appears. This angulation interferes with the passage of contents from the duodenal loop (Fig. 125, A).

A similar angulation may be produced at the greater curvature by angulation of the efferent loop toward the fundus. If the transverse mesocolon accentuates this angle an obstruction is produced which partially or completely blocks the efferent jejunum (Fig. 125, B). These two technical errors not only interfere with the passage of gastrointestinal contents but they distend the duodenum and favor leakage or rupture of its closed end.

Herniation of small intestine through the transverse mesocolon opening can usually be avoided if the left edge of the opening in the mesocolon is sutured to the posterior wall of the stomach before the anastomosis is done. The sutures should fix the mesocolon opening to the stomach about 1 inch proximal to the line of anastomosis. I feel that nonabsorbable sutures should be used to prevent the mesocolon slipping down over the line of anastomosis. The right leaf of the mesocolon opening can be applied and sutured most easily after the anastomosis has been completed and the stomach brought through the opening.

SUMMARY

While the importance of adequate duodenal stump closure in gastric resection is recognized by most surgeons, critical evaluations and contributions to strengthening and improving the closure have been sparse.

When resection is done for an ulcer on the vulnerable posterior wall of the duodenum, the difficulties of closure of the duodenal stump are greatly increased. In the case of hemorrhaging peptic ulcer, failure can be attributed frequently to the technical steps which do not efficiently prevent recurrence of hemorrhage. In many instances the bleeding is from an open eroded vessel which cannot be successfully approached, as it lies in the ulcer bed surrounded by pancreatic tissue. In these cases and in cases of pyloric stenosis due to edema and inflammatory infiltration resulting from the ulcer's penetration of the head of the pancreas, it is often extremely difficult to free up the duodenum from the pancreas and carry dissection beyond the ulcer. Even if one were successful in freeing up the duodenum, there would still remain the problem of mobilizing enough wall for an inversion which would be adequate to prevent leakage or actual disruption. There is also the dangerous possibility of involving the common duct in an adequate closure of the duodenum.

It is my feeling that too much emphasis has been placed on the necessity of resecting the ulcer itself, particularly in cases of penetrating posterior wall duodenal ulcers. Even the most chronic of these tend to heal when gastric secretion has been diverted.

A method of duodenal closure has been presented, which I have found particularly helpful, both in lessening the number of hemorrhages and in protecting the weak stump against the back pressure which under ordinary circumstances might encourage it to blow out. Hemorrhage is prevented by crowding the anterior wall of the duodenum down to act as a plug to the ulcer bed on the posterior wall. Pressure on the duodenal stump is alleviated by the transverse plication and narrowing of the duodenal lumen just proximal to the stump.

The various technical errors which lead to marked increase of intraluminal pressure of the duodenum can be avoided by scrupulous attention to the mechanics of the gastrointestinal anastomosis.

THE TECHNIC OF CHOLECYSTECTOMY AND CHOLECYSTOSTOMY

ARKELL M. VAUGHN, M.D. F.A.C.S.*

If the extrahepatic biliary system is abnormal cholecystectomy may be a difficult procedure requiring skill, ingenuity and surgical judgment. A cholecystectomy may be as difficult as a gastric resection and should be regarded as such. Many of the failures in gallbladder surgery result from a lack of knowledge about the peculiarities of this organ.

ANOMALIES OF THE GALLBLADDER EXTRAHEPATIC BILIARY PASSAGES AND ARTERIES

Anomalies of the Gallbladder—In a review of the literature Gross found seventy-three cases of congenital absence of the gallbladder. Maingot³ reports that he has seen double, bilobed and diverticular forms of the gallbladder. *Unusual positions* of the gallbladder are intrahepatic in the anterior abdominal wall on the left side, retrodisplaced, transverse and floating.

Anomalies of the Bile Ducts—The cystic duct varies in length, diameter, shape, configuration and relation to surrounding structures. Lichtenstein and Ivy¹ have dramatically shown these variations by sketches from the human cadaver (Fig. 126). Maingot³ shows that in some cases the cystic duct is absent. When this occurs the infundibulum enters the common duct by a wide mouth (Fig. 127, C).

The terminal portion of the cystic duct may be adherent to the lateral margins of the common bile duct for a variable distance, being fixed to the duct by bands of fibrous tissue (Fig. 126, 4 and 8, and Fig. 127, B). Lichtenstein and Ivy¹ point out the surgical importance of this, for numerous cases have been reported in which the common bile duct was injured during operation or mistaken for the cystic duct and ligated.

The cystic duct normally enters the common bile duct on the right side (Fig. 127, A, 1). According to Maingot,³ 8 to 10 per cent of the ducts may enter on the anterior surface (Fig. 127, A, 4), the posterior surface (Fig. 127, A, 5) or the left or medial side and swing spirally around the main duct posteriorly (Fig. 127, A, 3).

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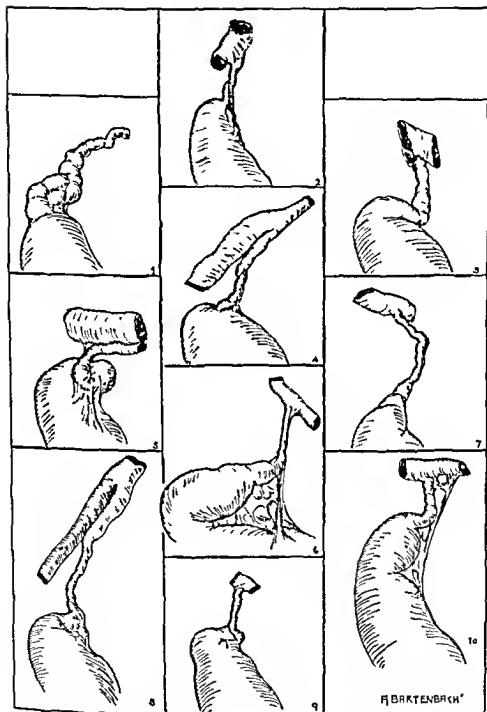


Fig 126—Variations in shape of cystic duct (Lichtenstein and Ivy¹). (Reprinted by courtesy and permission of the authors and publisher, The C V Mosby Co., St. Louis, Mo.)

Accessory bile ducts may be as large as the normal cystic duct, or they may be quite small. Failure to recognize injury to these ducts during cholecystectomy may result in a fatal bile peritonitis or an external biliary fistula (Fig. 127, D).

Anomalies of the Arteries.—The recognition of anomalies of the hepatic artery (especially the right hepatic) and the cystic artery and

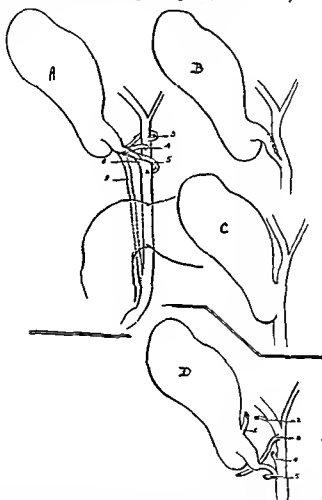


Fig 127—Anomalies of the bile ducts (Mangor²). *A*, The cystic duct may enter the common bile duct anywhere from just above the ampulla of Vater up to its normal entrance (N.B. Recently, while performing a Whipple operation for the removal of an early carcinoma of the head of the pancreas, we found the cystic duct entering the common bile duct just above its entrance into the duodenum [*A*, 2]. This anomaly should always be kept in mind during the removal of the head of the pancreas and duodenum for carcinoma.) An accessory cystic duct may open, *D*, 1, into the neck of the gallbladder, *D*, 2, into the right hepatic duct, *D*, 3, into the right side of the common hepatic duct, and *D*, 4 and 5, at a point at or very close to the site where the cystic and common hepatic ducts join (Reprinted by courtesy and permission of the publisher, D Appleton Century Co., Inc., New York and London.)

knowledge of the possibility of accessory cystic arteries is important in gallbladder surgery.

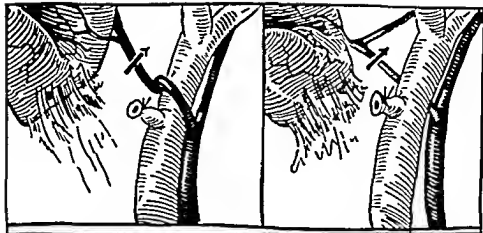


Fig 128—The right hepatic artery is liable to injury during cholecystectomy, as shown by Flint⁴ (cited by Maingot²), when '1 It lies parallel with and close to the cystic duct 2 It forms a loop in front of or a ring around the common hepatic duct 3 It projects markedly forward forming as it were a knuckle close to the upper margins of the neck of the gallbladder before sweeping backward to the portal fissure 4 The gallbladder has a mesentery, as in such cases the artery often lies within this on its way to the right lobe of the liver 5 It is dragged out of position by a sclerosing gallbladder

N.B. Recently during the dissection of a common bile duct we observed the hepatic artery crossing over the duct anteriorly. When lying in this position there is danger of clamping it during cholecystectomy (Reprinted by courtesy and permission of the publisher, D Appleton Century Co Inc New York and London)

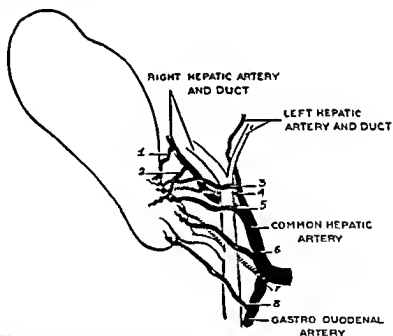


Fig 129—The great variations in the origin and course of the cystic artery (Maingot) (1) and (2) Cystic artery springs from the right hepatic artery in more or less usual position (3) Cystic artery arising from the left hepatic artery and passing to the gallbladder in front of the common hepatic duct (4) Cystic artery arising from the left hepatic artery and passing behind the common hepatic duct (5) Cystic artery arising at the junction of the hepatic arteries and passing in front of the common hepatic duct (6) Cystic artery arising from the common hepatic artery and passing toward the gallbladder in front of the common hepatic duct (7) Cystic artery arising from the common hepatic artery and passing behind the common hepatic duct (8) Cystic artery arising from the gastro-duodenal artery (Reprinted by courtesy and permission of the publisher, D Appleton Century Co, Inc, New York and London)

The *right hepatic artery* is likely to be injured during cholecystectomy, as shown in Figure 128

The *cystic artery* arises from the right hepatic in the majority of cases. It may, however, have many bizarre origins. These great variations are shown in Figure 129

Accessory cystic arteries may be single or double. They usually pass in front of the bile ducts. If they are unrecognized, severe hemorrhage may result during the dissection that is necessary for cholecystectomy

INDICATIONS AND CONTRAINDICATIONS

Indications for Cholecystectomy—Indications for cholecystectomy in the hands of an experienced surgeon may not be the same as in the hands of an inexperienced operator. Many times the pathology is such that it is much safer for the patient and wiser for the occasional operator to perform a cholecystostomy rather than a cholecystectomy. Nevertheless, there are certain generally accepted indications for cholecystectomy, which are as follows:

- 1 Cholelithiasis
- 2 Chronic cholecystitis with stones
- 3 Chronic cholecystitis without stones but with marked thickening of the wall of the gallbladder or pericholecystitis
- 4 Cholesterosis of the gallbladder (strawberry gallbladder)
- 5 Acute cholecystitis without marked edema of the gastrohepatic omentum or ligament (which usually occurs in the first forty-eight hours of attack) and without pericholecystic abscess
- 6 Most cases of internal or external biliary fistula and especially fistula following cholecystostomy
- 7 Mucocoele of the gallbladder due to a stone impacted in the cystic duct or neck of the gallbladder
- 8 Volvulus of the gallbladder
- 9 Gangrene of the gallbladder
- 10 Carcinoma of the gallbladder if no marked liver metastases are present
- 11 Innocent new growths of the gallbladder
- 12 In typhoid (bile) carrier
- 13 Contracted gallbladder

Contraindications to Cholecystectomy

- 1 A normal gallbladder
- 2 An acute cholecystitis with marked edema and swelling of the gastrohepatic omentum or pericholecystic abscess
- 3 Aged and infirm patients with cardiac, renal, pancreatic or pulmonary lesions and extreme obesity
- 4 A distended gallbladder and a common bile duct without stones due to obstruction in the common duct or ampulla

Indications for Cholecystostomy—Although cholecystectomy has been a popular operation in the past few years, cholecystostomy holds a very important place and may be considered a most significant operation in gallbladder surgery. Roger T. Vaughn, quoting from Deaver, states that after cholecystostomy '70 per cent of the patients

have no further symptoms.' In our early surgical practice we drained many more gallbladders for stones than we do now, with the result that the majority of patients experienced no further gallbladder distress. A very small percentage of these underwent cholecystectomy later. We recently saw at autopsy the gallbladder of a patient who had died of apoplexy. She had a cholecystostomy by an eminent Chicago surgeon nineteen years ago with the removal of 100 stones. The gallbladder appeared normal with no stones, and no evidence of the previous opening of the gallbladder was visible. The absence of adhesions in this area was an interesting observation.

Some of the indications for cholecystostomy are

- 1 Cholelithiasis with gallbladder wall grossly normal
- 2 An old or gravely ill patient
- 3 Extremely obese abdominal wall where exposure of the duct is difficult
- 4 Acute cholecystitis with inflammatory edema of the gastrohepatic omentum
- 5 Perforated gallbladder pericholecystic abscess and biliary peritonitis
- 6 As a preliminary measure in certain cases of acute cholecystitis with suppurative cholangitis and obstruction of the common bile duct
- 7 Traumatic rupture of a normal gallbladder
- 8 Empyema of the gallbladder

Contraindications to Cholecystostomy

- 1 Common duct obstruction by neoplasm with distention of the duct and gallbladder and without evidence of inflammation. Drainage would result in an external biliary fistula. A cholecystoduodenostomy, gastrosomy or jejunostomy would be the operation of choice.
- 2 In chronic cholecystitis with a stone impacted in the cystic duct the stone must be removed.
- 3 Acute cholecystitis when there is no edema of the gastrohepatic omentum, pericholecystic abscess or pericholecystitis which usually is not present in the first forty-eight hours of the attack.

PARTIAL CHOLECYSTECTOMY AND CHOLECYSTOSTOMY

In a few cases of gangrene of the fundus of the gallbladder it has been advantageous to do a partial cholecystectomy and a cholecystostomy. These patients are usually quite ill and there is much inflammatory edema in the area which makes visualization of the cystic and common ducts poor and dissection hazardous. The gallbladder is freed from above down near the neck of the gallbladder. The upper gangrenous part of the gallbladder is removed, and a hard rubber drain is inserted and sutured into the neck of the gallbladder. This removes the main areas of involvement and the tube allows drainage of bile and lymph to the outside, with the result that absorption is lessened and the biliary tree can be drained quickly. When edema subsides the drainage becomes less, and the external biliary fistula closes within a short time, provided the common bile duct is patent. The hepatitis subsides sooner. On the whole the operation is a safer procedure than total cholecystectomy.

PREOPERATIVE PREPARATION

Preoperative and postoperative preparation and care are as important to the patient suffering from gallbladder disease as the technique of the surgery. No elective patient should be operated upon without two or three days of preparation in the hospital. The following preoperative care may not be necessary in all cases but when indicated it should be carried out.

An acute upper respiratory infection or other infection must be removed before surgery is contemplated.

Oral hygiene should be cared for to rid the buccal cavity of any infection. Having the teeth thoroughly cleaned by a dentist is a worthwhile preoperative procedure.

Vitamin deficiencies should be corrected. Vitamin C given liberally preoperatively seems to promote wound healing. Vitamin K should be given liberally if there is or has been any indication of jaundice or lessened prothrombin time.

Reduction in weight slowly over a period of time is desirable in extremely obese individuals.

A roentgenogram of the chest and electrocardiogram are essential if any disease is suspected in the lungs or heart.

A complete gastrointestinal x ray is imperative to rule out stomach or bowel disease. A peptic ulcer may be responsible for the symptoms when a silent stone is found upon a flat plate x ray. Removal of the stone will not relieve the symptoms of the ulcer and hence no benefit is gained by the operation. If gallbladder disease is the cause of the symptoms removal of it will usually relieve the patient.

Urinalysis and complete blood count are necessary to rule out kidney and blood disease. Absence of urobilinogen in the urine indicates obstructive jaundice.

Blood chemistry studies should include nonprotein nitrogen, urea nitrogen, creatinine, icterus index, prothrombin time, serum protein and chlorides.

Adequate fluid balance with liberal intake of glucose and protein is indicated. The glucose is given in the form of hard candy by mouth for several days and 1000 cc of 5 per cent glucose in distilled water is given by venoclysis the day before surgery. Protein can be supplied by adequate meat diet and blood or plasma transfusion. Its need is shown by the plasma protein determination. The normal plasma protein is approximately 7 gm per 100 cc and an attempt is made to have it between 6 and 7 gm per 100 cc. Wound healing is greatly enhanced and there is also less danger of disruption of the wound or postoperative infection when the plasma protein is near normal.

Hippuric acid liver function test and other liver function tests if available and if indicated should be done if only for protective or prophylactic purposes. There is some question as to the surgical value of these tests but if the tests show a poorly functioning liver it is wise to postpone the operation and improve the function of the liver until a later date when the patient will be in a better condition to withstand surgery.

Cleansing of the lower bowel by a soapsuds or saline enema the night before surgery is indicated.

Nembutal, 1½ grains or some other barbiturate should be given the night before surgery and repeated at 7 A.M. on the day of operation. This usually insures a peaceful night and relieves apprehension the morning of surgery.

Accustom the patient with the use of the bed pan. This may prevent the need for postoperative catheterization.

Morphine sulfate, ¼ grain and atropine sulfate ⅓₁₅₀ grain one hour before surgery will insure a better anesthetic effect.

POSITION ON THE OPERATING TABLE

Most operating tables are equipped with a gallbladder lift which is placed under the lower ribs. This arches the body posteriorly slightly and elevates the epigastric region, thus bringing the liver and gallbladder forward. The table is then tilted in a reversed Trendelenburg position to about 15 degrees. This is the usual position. However, we occasionally place the patient on the table in a jackknife position with the knees flexed and the chest elevated. This relaxes the rectus abdominis muscles and brings the liver and gallbladder down. This has been found to be an advantageous position in some cases of gallbladder surgery. However, for common duct surgery I prefer the conventional position.

ANESTHESIA

We are using sodium pentothal (2 per cent) supplemented with cyclopropane and oxygen at the present time with satisfactory results. The sodium pentothal provides good relaxation.

When cyclopropane or ethylene is used without sodium pentothal, and if more relaxation is required, 3 cc of curare intravenously (Intocostin, Squibb) is given after the gallbladder has been exposed. This gives excellent relaxation for about thirty minutes during which time the ducts can usually be exposed, the gallbladder removed and the peritoneum closed. Occasionally an additional 2 cc may be required. Curare is a dangerous drug and should be given only by an experienced anesthetist who is equipped to give artificial respiration for the necessary period of time should respiratory paralysis occur.

My experience with spinal anesthesia in gallbladder surgery has been limited. However, if no contraindications exist, and if it is given by a qualified anesthetist, it is considered a good anesthetic for this operation.

INCISIONS

Numerous incisions have been described and employed in surgery of the gallbladder and biliary passages. The incision which preserves the nerve supply to the rectus abdominis muscle and at the same time gives adequate exposure to the gallbladder and bile ducts is naturally the one of choice. For this reason I have employed two types of incision in the past few years, namely:

- 1 *The vertical right upper paramedian* from the xiphoid to a point to the right and below the umbilicus (Fig. 130). This is the one most commonly used, and it gives the best exposure in the majority of cases. The rectus abdominis muscle is retracted laterally, thereby preserving the nerve supply to the entire muscle.

- 2 *The Gurd's transverse incision* with or without division of the rectus abdominis muscle, and preferably without division of the muscle if adequate retraction and exposure can be obtained (Fig. 130). The skin incision is carried from slightly to the left of the midline to

the tip of the twelfth rib on the right side. The incision is usually 2 cm. above the upper border of the umbilicus and below the middle inscriptio tendineae and is carried down through the skin and subcutaneous fascia to the anterior sheath of the rectus abdominis muscle and external oblique muscle and aponeurosis. The external oblique and internal oblique muscles are split in the direction of their fibers, the

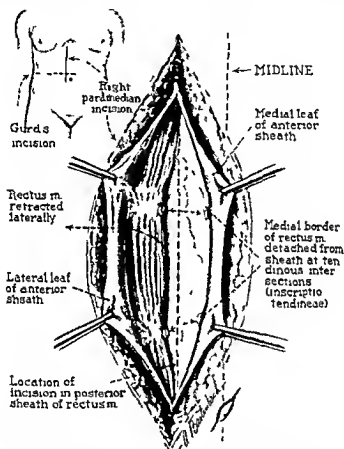


Fig. 130—Diaphragmatic drawing showing structures encountered in the vertical right upper paramedian incision. Inset shows location of the Gurd's and right paramedian incisions.

interior sheath of the rectus abdominis is cut transversely and the rectus muscle is retracted medially. The posterior sheath of the rectus abdominis muscle, transversalis fascia, transversus muscle and peritoneum are cut transversely and the abdominal cavity opened. If exposure is difficult, the right rectus abdominis muscle may be divided transversely. The ninth intercostal nerve can be retracted medially and preserved. While the exposure in this type of incision is not always

the best and adequate retraction is essential, the patients on the whole have a smoother convalescence and less postoperative pain. Drainage tubes if used can be brought out through the lateral margin. This incision is especially desirable in tall, thin patients.

The oblique incision in our hands has proved unsatisfactory, since the incidence of postoperative hernia has been greatest with this type of incision.

TECHNIC OF CHOLECYSTECTOMY

The skin is prepared by painting the abdomen from the nipples to the pubes with any one of the numerous antiseptic solutions. A ten minute green soap scrub may be used. The field is then draped.

1. Incision.—The vertical upper right paramedian or Gurd's transverse incision is carried through the skin and subcutaneous tissue. Skin towels are applied to the skin edges and secured with clips. If the vertical incision is used, the anterior sheath of the rectus abdominis muscle is cut longitudinally in its median one-third (Fig. 130). The muscle is dissected from the midline. The two upper insertions of the tendineae firmly attach the muscle to the midline. Blood vessels are encountered in the tendineae and must be secured by a suture-ligature since a simple ligature alone may slip from the cut edge of the fascia. The entire rectus abdominis muscle is retracted laterally after a moist warm lap pad is placed over it. This lap pad protects the muscle from trauma exerted by the retractor. The peritoneum and transversalis fascia are cut vertically about 1 inch from the midline since the lateral border has a tendency to retract under the muscle. It is important in closing the peritoneum to include both these layers, for failure to include the transversalis fascia may result in a postoperative hernia. The peritoneal incision is made about 1 inch shorter than the fascia incision, which in turn is made 1 inch shorter than the skin incision. These steplike incisions in the anterior abdominal wall facilitate closure, especially at the ends of the incision.

2. Exploration.—A systematic exploration of the abdominal cavity is done if there is no acute infection present. The liver is palpated and its color noted. A sharp liver edge indicates a normal liver, while a rounded swollen edge indicates disease, such as hepatitis. The forefinger of the left hand is placed in the foramen of Winslow, if normally patent, and the extrahepatic bile ducts are palpated for stones or growths. The gallbladder is palpated for stones, growths and thickness. The duodenum and ampullary region and head of the pancreas are palpated as are the stomach, entire colon, kidneys, spleen and pelvic organs. Lastly, the hand is brought out of the abdomen with the cecum and appendix. If a pathologic condition is found in the appendix, it may be removed at the end of the operation provided that no trouble was encountered with the cholecystectomy and the condition of the patient is satisfactory.

3. *Exposure.*—A self-retaining abdominal retractor is placed in the wound. Moist laparotomy pads are placed over the transverse colon and the stomach down to the duodenum (Fig 131). A Deaver or, preferably, a medium wide flexible retractor is placed over the laparotomy pads down to the root of the mesentery. By retracting obliquely downward and to the left, the duodenum is flattened out and

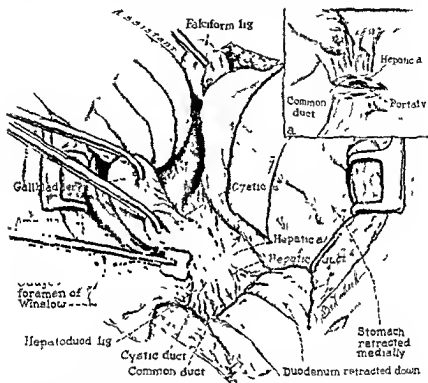


Fig 131—The exposure in cholecystectomy showing relation of gallbladder to the foramen of Winslow, hepatoduodenal ligament and surrounding structures. Inset (a) is a cross section of the hepatoduodenal ligament which is the thickened right border of the greater omentum and forms the anterior boundary of the lesser peritoneal cavity. Three important structures course through it: (1) the common bile duct to the duodenum, (2) the hepatic artery, and (3) the hepatic vein beneath and between the duct and artery.

the hepatoduodenal ligament is exposed. The stomach, colon and omentum are not visible in the wound. Assistants retract the right and quadrate lobes of the liver upward, preferably with their fingers encompassed with moist gauze to protect the liver from trauma. A strip of gauze is inserted into the foramen of Winslow if patent (Fig 131). This prevents blood and bile, if any leakage occurs, from entering the lesser peritoneal cavity.

4 Exploration of the Common Bile Duct—If there is any uncertainty about obstruction in the common bile duct after manual exploration and palpation it must be opened and explored. The results of this exploration will determine whether the gallbladder should be removed or drained. If an irremovable obstruction is found, cholecystectomy will have to be abandoned. If the cystic duct is patent and the condition of the gallbladder satisfactory, the surgeon can perform a cholecystoduodenostomy preferably, or a cholecystogastrostomy or cholecystojejunostomy. If the cystic duct is obstructed and the gallbladder is not useful, a choledochoduodenostomy is an alternative. Some surgeons almost routinely open and explore the common bile duct if stones are present in the gallbladder. I do this only if I think the individual case demands it. Blake's flexible common duct dilators are satisfactory for probing and dilating the intraduodenal portions of the common bile duct.

5 Removal of the Gallbladder from the Fundus Down—If cholecystectomy is decided upon rather than cholecystostomy, the next question is whether to remove the gallbladder from the fundus down or from the cystic duct up. This depends upon several factors including the operator's capability, choice or experience, the condition of the patient, and the pathologic condition found in the gallbladder and surrounding structures. If the gallbladder is surrounded by dense adhesions or there is a large gallstone in the ampulla which distends the duct or if the cystic duct and hepatoduodenal ligament are edematous, dissection from the fundus down is indicated. The technic is relatively simple and is performed as follows:

ly from the gallbladder with moist laparotomy
sistended Apply traction to the fundus of the
placed over the aspiration hole Separate ad
hesions and dissect the fundus and body of the gallbladder from the liver bed
down to the cystic artery and duct Clamp cut and doubly ligate the duct and
artery either singly or together with No 1 chromic catgut the distal ligature
being transfixed to the duct or surrounding tissue to prevent it from slipping (Fig
132) Then remove the gallbladder The bed of the gallbladder is sutured with
continuous No 0 plain catgut to control the bleeding and to attempt to prevent
the formation of adhesions (Fig 133, B) A cigarette drain usually is placed near
the amputated duct and brought out of the abdominal cavity through a stab
wound in the right side (Fig 135) The abdomen is closed in layers as will be
described later

This method may be quite bloody since blood oozes from the cut surfaces of the liver and gallbladder until the cystic artery is ligated, obscuring the operative field.

I rarely employ this procedure although its comparative safety is recognized.

6 Removal of the Gallbladder from the Cystic Duct Up—If it is decided to remove the gallbladder from the cystic duct up, the

bladder may first have to be aspirated if it is tense or edematous. A curved forceps is placed over the aspiration hole to prevent leakage of infected bile (Fig. 131). The forceps is pulled upward and forward until the ampulla is exposed and the liver brought up into the wound. Next a second curved forceps is placed on the ampulla (Hartmann's pouch) (Fig. 131). Traction on this will draw the cystic duct to the right, almost at a right angle to the common bile duct. Traction will

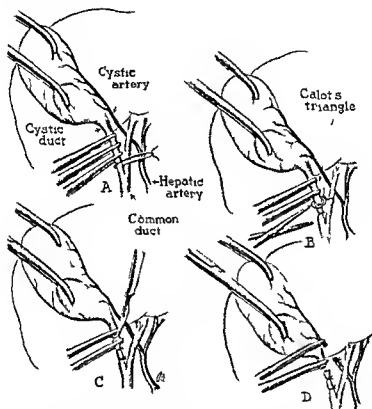


Fig. 132—Ligation and division of the cystic duct and artery. *A* Three forceps applied to cystic duct. *B* Transfixion of distal ligature on proximal stump to prevent slipping. *C* Cutting duct between two distal forceps. *D* Doubly ligated stumps of cystic duct and artery.

also stretch the hepatoduodenal ligament. The peritoneum and fat over the ampulla are carefully incised and the cystic duct is exposed and dissected down to the common duct. The hepatoduodenal ligament is carefully dissected with a small piece of umbilical tape rolled and attached to a long forceps. The common bile duct is exposed and the junction of the cystic duct with the common bile duct and gallbladder is viewed remembering the anomalies of the ducts and arteries in this area previously mentioned. This dry dissection with tape under

direct vision is as valuable here as in blood vessel surgery, where it was conceived. A right-angled gallbladder forceps is then passed into Calot's triangle between the cystic duct and artery and its jaws opened for further dissection if necessary.

7. Ligation of the Cystic Duct—The cystic duct is clamped with three curved gallbladder forceps if the duct is long enough. If not only two forceps are used. The duct is cut between the two distal forceps (Fig. 132). The proximal forceps should be applied sufficiently far from the common duct to allow room for its ligation without encroachment upon the common duct. The cystic duct is ligated around the proximal forceps, and then a second transfixing suture is placed near the second forceps with the same suture material. Four knots are made and the ligatures cut $\frac{1}{2}$ inch from the knot for security. A ligature is placed around the distal clamp and neck of the gallbladder to prevent spillage of bile, should this distal clamp inadvertently be come released or slip off.

8. Dissection and Ligation of the Cystic Artery—The remaining fatty tissue lying between the site of the cystic duct and the liver contains the cystic artery. This is carefully dissected and the cystic artery adequately exposed. The cystic artery is clamped with three curved artery forceps, care being taken not to include the hepatic artery. Some authorities believe that many of the so called "liver deaths" result from clamping the main hepatic artery or its right branch during this stage of the operation. The cystic artery is cut between the two distal forceps and doubly ligated with chromic No. 1 catgut, the distal ligature being transfixed (Fig. 132). Four knots are made, and the ligature is cut 1 inch from the knot. This is better assurance that the ligature will not loosen or become untied. The cystic artery is always ligated as soon as it is cut and before the gallbladder is removed. The clamps may be accidentally loosened or pulled off, with resulting annoying hemorrhages. Should this accident occur or should there be an accessory cystic artery present which was unrecognized before cutting, do not try to stop the hemorrhage by blindly clamping into the bloody field. Instead place the index finger of the left hand into the foramen of Winslow and compress the hepatic artery in the hepatoduodenal ligament between the forefinger and thumb (Fig. 131). This will stop the active hemorrhage. Next sponge or aspirate the blood from the field and when it is dry have an assistant ready with a forceps to grasp the spurting artery as soon as pressure is gradually released. Then ligate the vessel. This will prevent damage to the surrounding tissue. The foramen of Winslow is quickly found since the end of a piece of gauze was previously placed into it after exploration (Fig. 131). This maneuver has and will save the surgeon many anxious moments.

The cystic duct and the cystic artery may be clamped together if they are in immediate proximity, as they often are. The technique of

clamping and ligating is the same as mentioned previously for the individual ducts

It is difficult to separate the neck of the gallbladder from the infundibulum when the cystic artery is intact, since the artery crosses both of these divisions and fixes them together. However, when the cystic artery is divided, these structures are readily freed, and dissection from the liver bed is facilitated. Thus freeing of the neck and

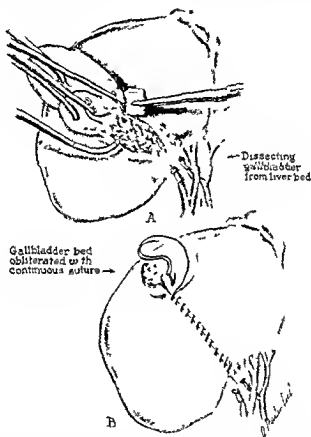


Fig. 133—Removal of the gallbladder from its bed and caring for the bed. *A*, Sharp and dry dissection is used. *B*, Closure of the gallbladder bed by continuous suture No. 0 plain catgut.

infundibulum reasonably assures the surgeon that the cystic artery has been secured.

9 Removal of the Gallbladder from Its Bed—The distal forceps attached to the cystic duct is rotated anteriorly, and gentle traction is applied to the forceps attached to the fundus and Hartman's pouch. This makes tension on the peritoneal attachment from the gallbladder to the liver (Fig. 133, *A*). An Orr gallbladder knife, or my modifica-

tion of the Orr knife (Fig 134), is inserted under the peritoneum at the neck of the gallbladder where the peritoneum was previously opened. The peritoneum is cut first on one side and then on the other, and the gallbladder is removed from its bed. Sometimes a scalpel or curved dissecting scissors has to be used for this procedure when the serosa is thickened. A liberal amount of gallbladder serosa is left attached to the liver to facilitate suturing the resulting raw surface. This dissection is facilitated in some instances by injecting saline solution under the peritoneum of the gallbladder near its attachment to the liver.

10 Caring for the Gallbladder Bed—Any bleeding other than simple oozing should be thoroughly controlled. Pressure with a lint, moist

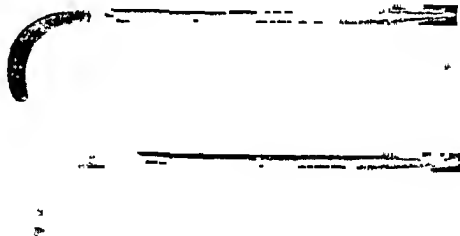


Fig 134—Top, Orr's gallbladder knife. Bottom, author's modification of Orr's knife. A triangular blunt end similar to one blade of dressing scissors has been added. These knives facilitate the dissection of the gallbladder from its bed.

laparotomy pad in the gallbladder bed will usually control the oozing. If not, a strip of muscle from the rectus abdominis muscle may be placed in the bleeding area to aid in controlling the bleeding. The two serosal flaps left at the sides of the fascia are usually sutured. A continuous suture of plain No. 0 catgut is used, beginning at the lower portion of the wound and ending at the upper margin of the liver (Fig 133, B). This closure prevents bleeding from the serosal flap and may aid in preventing the formation of adhesions to the gallbladder bed. When the fascial edges fold together and approximate the flaps and when there is no bleeding, suturing of the bed is unnecessary.

11 The Use of Drains—A cigarette drain is usually brought out through a stab wound in the right flank below the tip of the eleventh

rib (Fig. 135). It is placed in the vicinity of the foramen of Winslow and the severed cystic duct. The drain is advanced daily and removed on the third postoperative day. I never drain through the incision if it can be avoided, since this tends to weaken the abdominal wall and is a predisposing factor in postoperative incisional hernia. Occasionally when the gallbladder has been dissected easily with little bleeding and the field is exceedingly dry, the incision may be closed without drainage. When in doubt it is best to drain.

12. Closure of the Abdominal Wall—A McNealy rubber lap pad of medium size is placed in the wound. This protects the viscera and aids

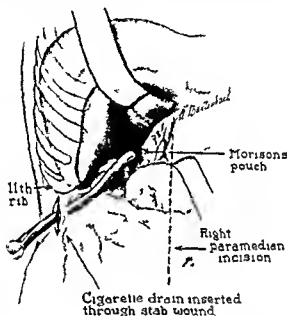


Fig. 135—Drain inserted through stab wound in right side. Drains inserted through the abdominal incision are avoided if possible since they may lead to the much dreaded postoperative incisional hernia.

in closure of the abdominal incision. It is removed through a small opening at the lower end of the incision just before the peritoneum is closed. The peritoneum and transversalis fascia are closed with a double continuous locked chromic No. 0 catgut suture beginning at the upper end. The *inscriptio tendineae* of the rectus abdominis muscle are sutured to the midline with plain No. 0 catgut and the muscle returned to its normal position. The fascia is closed with a double continuous locked chromic No. 1 catgut suture and the suture is cut rather long to prevent slipping. Several additional interrupted sutures are taken in the fascia if early ambulation is anticipated. The subcutaneous fat is approximated by several interrupted plain catgut sutures.

In very obese patients three interrupted silkworm sutures are used to obliterate the dead spaces and to relieve the tension on the skin incision. The skin is approximated by a continuous locked suture of medium sized dermal.

POSTOPERATIVE CARE

The following routine postoperative orders for cholecystectomy have been used and found satisfactory:

- 1 Pantopon $\frac{1}{2}$ grain for pain (if present) every three hours for forty-eight hours
- 2 Nothing by mouth for twenty four hours
- 3 Five per cent glucose 1000 cc in saline intravenously immediately after surgery to run at 60 drops per minute and containing one ampule Sclu B and one ampule Cevalin. Repeat the following morning
- 4 Five per cent glucose 1000 cc in distilled water on the afternoon of surgery to be finished by 9 P.M. Repeat the following afternoon
- 5 Take the blood pressure every two hours for the first eight hours and three times a day until it is stable
- 6 In case of shock give (a) plasma 250 or 500 cc., as fast as possible (b) adrenal cortical extract (Upjohn) 1 cc every three hours until blood pressure is stable
- 7 In case of bleeding give Synkamin (vitamin K) one ampule. Repeat in four hours
- 8 Wangenstein suction if emesis and distention occur
- 9 Oxygen 4 liters per minute if necessary for marked abdominal distention
- 10 Rectal tube if necessary for gaseous distress or distention
- 11 Prostagmine 1:4000 one half ampule every four hours for four doses if needed on second or third day for gaseous distress and distention or urinary retention
- 12 Have the patient take deep breaths and move his legs fifteen minutes out of each postanesthetic waking hour while confined to bed. This is a prophylactic measure against atelectasis of the lung or phlebotrombosis in the extremities
- 13 Sips of warm tea or water after first twenty four hours if tolerated. Increase fluid intake orally as tolerated
- 14 Soft diet on third postoperative day
- 15 Oil retention enema on third postoperative night. Water flushing on the fourth postoperative morning
- 16 Advance drain if any daily until completely removed on the third or fourth postoperative day
- 17 Remove sutures on tenth postoperative day. Place tape bridges over wound and firmly taped dressings
- 18 Scultetus handage on early ambulatory patients

TECHNIC OF CHOLECYSTOSTOMY

As previously stated, cholecystostomy still has its place in gallbladder surgery. The indications have previously been given. The technic is as follows:

- 1 The position on the table and the incision are the same as for cholecystectomy
- 2 The anesthetic is likewise the same except for extremely ill bedridden or old patients. Infiltration of novocaine is used to block

the field This may have to be supplemented by sodium pentothal or gas

3 Explore the extrahepatic biliary passages, gallbladder and abdomen if the gallbladder is not acutely inflamed, edematous, or walled off by fresh fibrinopurulent adhesions If the above pathologic changes are present, it is better not to attempt to break up nature's way of walling off the infected gallbladder

4 The edges of the wound and the region around the gallbladder should be walled off by moist laparotomy pads These pads will collect the highly infectious bile which may be spilled

5 Two Allis forceps are applied to the fundus $\frac{3}{4}$ inch apart and a trocar introduced between the forceps The fluid contents of the gallbladder are aspirated

6 The trocar opening is enlarged with scissors, and the edges are grasped with three Allis forceps which are placed equidistant apart

7 Remove stones if present with a gallstone forceps or scoop Cleanse the cavity with a piece of dry gauze, since small calculi may become enmeshed in this gauze Insert a finger in the gallbladder to make sure that no stones are left in the ampulla and cystic duct If any are detected the index finger of the left hand is placed under the cystic duct and the neck of the gallbladder and the stones dislodged into the lumen of the gallbladder and removed

8 A rubber drainage tube $\frac{1}{4}$ inch in diameter and 6 to 8 inches long is inserted into the gallbladder as far as it will go and then brought out two thirds of this distance This will prevent pressure necrosis by the tube at the neck when the gallbladder is inverted

A continuous Lambert stitch of No 0 plain catgut encircles the opening in the gallbladder All the layers of the gallbladder are included and the rubber tube is secured at two points opposite each other The tube is firmly anchored and the opening in the gallbladder closed by this stitch

A purse string suture of No 1 chromic catgut is next placed around the tube about $\frac{1}{4}$ inch below the previous one The gallbladder is inverted by this stitch Occasionally a second purse string suture is inserted for further invagination The fundus of the gallbladder should not be sutured to the anterior abdominal wall

9 The tube is usually brought out through the abdominal wall in cision or through a stab wound in the right side Usually no abdominal drain is necessary If drainage is necessary, a stab wound on the side as described under cholecystectomy is advisable (Fig 135)

10 The abdominal wall is closed as described above The post operative care is the same as for cholecystectomy

SUMMARY AND CONCLUSIONS

1 Important anomalies of the gallbladder, extrahepatic ducts and arteries are described

- 2 Some indications and contraindications for cholecystectomy and cholecystostomy are given.
- 3 A routine of preoperative and postoperative care is outlined
- 4 The technic of dry dissection of the ducts by a small piece of umbilical tape clamped to a forceps is described
- 5 Early cutting and ligation of the cystic artery simplifies the freeing of the neck of the gallbladder and infundibulum
- 6 The author's modification of the Orr gallbladder knife is used in freeing the peritoneum around the gallbladder bed
- 7 The use of muscle in stopping oozing from the gallbladder bed is mentioned
- 8 The importance of stab wound drainage away from the abdominal incision is emphasized
- 9 The judicious use of curare (Intocostin, Squibb) is mentioned when better relaxation is needed. Curare is used for complete muscular relaxation

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TREATMENT OF FRACTURES OF THE HIP, SURGICAL TECHNIC

KELLOGG SPFEH, M D , F A C S *

THIS clinic deals with technical procedure in the treatment of fractures of the hip. The anatomy of the hip area will not be covered, but these important characteristics should be remembered: the angle of the neck of the femur with the trochanteric portion normally 130 degrees, the angulation upward of 15 to 20 degrees of the neck into the head to meet the acetabulum, the magnificently arranged crescentic bony lamellae in the neck and head of the femur for the safe transmission of weight bearing, the provision of blood supply to the neck and head from periosteal and nutrient vessels, the inconstant and relatively smaller blood supply via the ligamentum teres, the inclination of the acetabular cavity slightly forward and outward, its depth, the character of its margins, the insertion of the strong capsular ligament of the hip joint into the intertrochanteric line anteriorly and the neck at a higher level posteriorly, and the support and influence of the ilio femoral ligament (Y ligament) in manipulation and as retention aid after reduction of fracture at the neck of the femur. The strong osseous bar, the calcar femorale, extending from the head down into the trochanteric portion of the bone where it spreads out to take base should not be forgotten because restoration of its axis and aid of its regenerated supporting lamellae are of great influence in the technic of repair of fracture and insurance of its stability.

OPERATIVE TREATMENT FOR RECENT FRACTURES AT THE NECK OF THE FEMUR

Whether the fracture is subcapital or near the base of the neck slightly comminuted or accompanied by partial luxation of the head or by fracture of the lip of the acetabulum manipulative reduction and restoration of contact between the fracture surface of the head and neck fragments preferably should be obtained with a slight position of coxa valga to insure pressure impaction and ultimate reestablishment of trabecular lines. The position of reduction must be confirmed by roentgenograms of the hip, both anteroposterior and lateral.

Operation to secure the reduction, which has been confirmed by roentgenological examination in two axes, is best performed on a frac-

From the Surgical Department of the Presbyterian Hospital and the University of Illinois College of Medicine Chicago

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ture table with suitable pelvic rest and pin to hold against the perineum. The leg bars and foot attachments are required to hold the reduced fracture mechanically without further attention by the surgeon, who may rely on his own reduction and fixation on the table, however obtained even at times with the help of skeletal traction and support through the lower end of the femur, the crest of the tibia or the calcaneus.

The best operative technic does not always produce a bony union of the neck of the femur capable of bearing the weight of the body and of functioning with reasonable success. The operation leads in some instances to septic necrosis of the head of the femur with breaking down and flattening of cartilage and bone, loss of joint space with pain in the hip and finally lack of movement. There may be errors of omission or commission in the operation.

Errors of Omission—1 Incomplete preparation of a sterile operating field with resulting wound infection.

2 Failure of roentgenologic control during the process and at the end of fixation. The lateral view is particularly necessary to be sure that the head of the femur rides in proper position on the neck. If the head of the femur is not properly placed the following may result:

- a Insufficient penetration into the head of the femur by the fixation agent because it is too short or incompletely inserted.
- b Too deep a penetration extending into the acetabulum. This may lead to separation at the fracture plane.
- c Rotation of head fragment during insertion of fixation after insecure reduction or improper angle of insertion. This will lead to loss of contact of fracture surfaces.

3 Improper postoperative fixation and care to avoid stress on the fixation. This may lead to disjunction.

Errors of Commission—1 Incomplete reduction of the fracture. Remember the advantage of a slight *cova valga*.

2 Improper angle of insertion of fixation agent because of ignorance or disregard of anatomy.

3 Lack of immediate checking roentgenological control. The operator may be too hurried or overconfident. Don't put off the check up for several days.

4 Lack of aseptic technic and unskilled operating depending too much on mechanical pointers or indicators.

5 Insufficient support of the leg after operation by whatever means the patient requires.

6 Too early unguarded motion especially abduction of the leg. The nurse must be familiar with the angle of the neck and the delicacy of handling a fine adjustment.

7 Too early weight bearing putting too much faith in the fixation.

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the angle or declination of the neck of the femur, 15 to 20 degrees forward, they give an almost complete guide for internal fixation.

Other mechanical pointer and director devices are numerous. Some of them are cumbersome and expensive and may endanger the asepsis of the operation. Few experienced operators use them. After much experience a surgeon may select his determining points by surface anatomical landmarks, but no matter what his experience may be, he

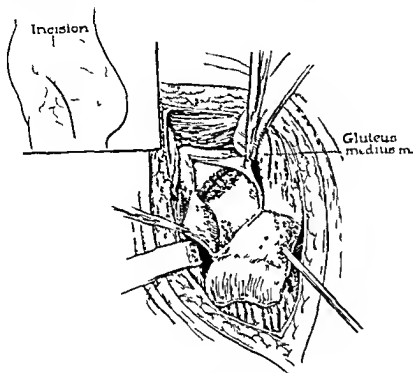


Fig 136—Method of pinning fracture of the neck of the femur by the open method. The large incision which exposes the hip joint widely is illustrated in the upper corner. The capsule has been split open widely, the pin entered at a point well below the greater trochanter. By rotation of the leg the exact point of exit of pin from the trochanteric fragment and its intended entrance into the hip may be visualized. This requires extensive dissection and may not be required if proper roentgenologic control is available. This nail would be better placed at the lower corner of the fracture just along the inferior border of the neck to conform with the normal arrangement of the strongest bony lamellae. (From the author's textbook on Fractures and Dislocations 4th ed. Lea & Febiger Philadelphia.)

should never neglect roentgenological control before final insertion of the fixation.

So called 'blind nailing' may be successfully done on occasion, but the time will come when the operator will make a major error. The steps described with simple markers are obscure enough, and they do not rest completely on a mechanical pointer or range finder. The most important step is the assured penetration of the properly reduced head as seen in the lateral view of the hip.

The Incision—This depends on the type of fixation to be used the dexterity of the operator and his ability to rely on roentgenologic help for confirmation of the correct angle and position of the fixation agent without having to see the neck and head of the femur or the fixation as it passes the fracture plane (Fig. 136)

A complete exposure of the hip area requires an incision from the anterior superior spine of the ilium down and outward to the tip of the trochanter of the femur and then curved or angled down the long axis of the shaft of the femur for 4 inches or more. This long incision



Fig. 137



Fig. 138

Fig. 137—An apparently excellent reduction of fracture of neck of femur with good apposition of fragments held by Smith-Petersen nail. Proper position of head of femur confirmed by lateral x-ray. No infection. Head viable. The angle of this nail is not sufficiently oblique.

Fig. 138—Same hip six months later. The nail holds into head. No union at neck with rise of trochanter and shortening. No infection. The head is now dead. The fault in this instance may be the incompletely oblique angle of insertion of the nail plus too early weight bearing relying on the pin for support and not waiting for firm lasting bony union. Pin and head were removed by the surgeon on account of severe pain. (Both illustrations from the authors' textbook on Fractures and Dislocations, 4th ed. Lea & Febiger, Philadelphia.)

exposes many bleeding points. As the fascia and muscles beneath are cut through and reflected from the anterior surface of the neck and the trochanteric portion of the femur, much more bleeding is encountered requiring ligation and delay until the neck of the bone and hip joint capsule may be visualized.

This exposure of the joint capsule is seldom warranted in recent fracture. It may be necessary with dislocation or subluxation of the head where replacement of the head or fixation of a fragment of the broken acetabulum becomes an integral part of the operation to maintain reduction.

The hip joint capsule when exposed may be split longitudinally and the fracture plane brought into view. These operations almost invariably require whole blood transfusions while the patient is on the table.

A small incision is usually sufficient, starting just below the tip of the trochanter of the femur, passing down on the long axis of the shaft near its posterior margin usually parallel to the surface of the table, about 3 or 4 inches long. If the patient is not obese by splitting the fascia lata there is only a thin layer of muscle to separate in the same axis before the upper end of the shaft of the femur is in clear view. The opening, after necessary ligation of bleeding points is gently retracted up and down. The operator palpates or determines by



Fig. 139—Fracture of neck of femur in a 74 year old woman. Leg rotated outward.

feeling with a sterile instrument a point about 2 inches below the tip of the trochanter well on the posterior aspect of the shaft.

The point of entrance of the fixation agent employed must be at the greatest oblique angle of the reduced fracture of the neck of the femur along the underside of the neck without damaging the cortex or passing below it well into the head fragment. This angle conforms to the anatomical arrangement of the supporting trabeculae of the neck and takes up the function of support with a naturalness which may obviate untoward stress, pressure or cutting into the soft cancellous bone. Entering at this angle may promote healing without migration of the fixation agent in any direction. Fixation through the trochanter at a right angle or less into the head does not coapt fragments well. Fixation thus applied must take up the stress of movement dur-

ing bone healing, and the agent may migrate in response to the stress of the angulation of the fracture plane or develop a tendency to cut into the bone by pressure and thus loosen the holding contact (Fig 138) After a $\frac{1}{16}$ inch drill hole is made obliquely into the point of entrance, a dull-pointed Kirschner wire or very narrow Steinmann pin, over which the fixation may fit, is inserted slowly by drill or hammer while the operator gets the "feel" of the penetration. When



Fig 140



Fig 141

Fig 140—Same fracture shown in Figure 139, reduced by manipulation with slight coxa valga, position of head confirmed by lateral film, patient lying fixed on fracture table with skeletal support through calcaneus. On the surgically prepared skin of the hip have been sewn parallel to each other, the two tin strips with perforated digits. The small holes at the ends of the strip are for fixation suture to skin. The x-ray film indicates the direction required by the fixation agent to pass through the lower angle of the fracture near the cortex of the neck on into the head. One may select in this instance from No. 4 to No. 4 or No. 4 to No. 5, or No. 5 to No. 5. One Moore pin already partly inserted, a second one started.

Fig 141—Three pins now inserted. Ready for removal of the tin guide strips by snipping away sutures holding them to skin.

he reaches the fracture plane, this "feel" will change—there will be less resistance. Before proceeding to further penetration an x-ray film must be obtained in two planes, anteroposterior and lateral, to be certain that the head is about to be entered at the suitable point. If the axis of this "feeler wire" is not satisfactory it is easily withdrawn and reinserted, to be checked again by x-ray.

The operator has prepared the fixation agent he prefers or is best qualified to use. Let us say he has two sizes of Smith-Petersen three



Fig 142



Fig 143

Fig 142—Same hip five and one half months later. Pins remain in good position. Their ends were not wired together. Bony union seems accomplished as trabeculae are now seen crossing old fracture plane. Patient now ready for beginning weight bearing.

Fig 143—Lateral view of same hip confirming position of head and bony union with well established trabeculae and position of Moore pins unchanged.



Fig 144



Fig 145

Figs 144 and 145—Same hip eleven months after pinning postero anterior and lateral views. Union seems good, strong bony lamellae, neck angle good, tracks of nails (long since withdrawn) still visible. Patient has borne weight five months.

flanged nails or a set of Moore's pins of varying lengths which may be cut off after insertion at levels required. If the Smith Petersen nail is used it requires a suitable opening in the outer cortex of the femur near the posterior aspect immediately around the entrance of the Kirschner wire or the direction pin employed. This opening may be made accurately through the cortex with a sharp small gauge and mallet. A little more delicate and accurate opening always in the axis of the determining wire, may be made by machining with a cannulated Meekison facer, but this is not always available. The nail is then



Fig 146



Fig 147

Fig 146—Fracture of neck of femur slightly comminuted in a woman over 70 years of age. Usual displacement. Patient had gone untreated for several weeks.

Fig 147—After reduction of neck of femur with fixation on tibia this anteroposterior view shows the amount of comminution of the neck and the lateral skin marker with two Moore pins partly inserted. The lower pin must be withdrawn as it will fail to enter the head lying below the inferior border of the neck. Proximal marker does not show in this film.

driven in over or parallel to the guide wire and the surgeon notices the increased resistance as it crosses the fracture plane into the bone of the head. It is not driven to final position until the roentgenological film certifies as to depth of penetration into the head and the angle of the head on the neck. The omission of this step leads to most of the failures of operative fixation. One of the most important precautions is a careful asepsis and nontouch technic with all materials which penetrate the wound and especially the bone.

If Moore's pins are used three or more may be entered parallel to the primary guide wire. Sometimes they are used in groups of two

each, one at the lower margin of the neck cortex, the other near the upper margin

Autogenous bone transplants may be used in recent fracture. They add nothing, however, to the fixation or the certainty of the bony union to follow, which depends on correct reduction, apposition and protection to insure a returning and lasting blood supply. Obtaining the transplant requires much extra time, more surgical apparatus and usually an extra surgical team for that purpose alone.



Fig. 148



Fig. 149

Fig. 148—Lateral arrangement after insertion of three Moore pins the long ends of which may be cut off. This position of reduction was confirmed by lateral roentgenogram.

Fig. 149—Same hip as Figure 148 seven months later after another fall. The patient had been at home but not bearing any weight on this leg, using crutches. The second fall had broken two pins, one still held. Bony union had been progressing. There was immediate pain after second fall and loss of power to move limb as she had been doing.

The nail or pins should not be fixed to the cortex of the femur lest retraction or migration occur. Moore's pins do not require wiring together. The firmness without undue pressure of the fixation agent in the low cortical margin of the neck insures its stability and a minimum amount of local bone necrosis from pressure. When the fixation nail or pin is anchored at the external cortical margin, separation of fragments at the fracture plane may result if any subsequent bone soften-

ing ensues during the fracture repair. Various forms of lag screws and nails which are designed to pull the head down onto the neck may obviate this separation. If the Moore pins are too long and project unduly they can be cut off at a level distal to the fixation nut which lies in apposition with the edge of the femur.

The operative wound is closed by interrupted buried sutures of catgut or silk in the fascia and a similar stitch of black waxed silk in the skin. A small dressing held by adhesive tape to exclude the area from local contamination is applied.



Fig. 150—Lateral view of hip shown in Figure 149. The evidence of the progressing bony union and the two broken pins are evident. Further operative effort was refused. The patient went onto final bony union with a coxa vara and leg shortening.

Postoperative Care—A Thomas leg splint is applied to some patients to cradle the leg with the knee slightly flexed, suspended or supported enough to be of help in the use of the bed pan, to avoid any rough handling in nursing care and to give the patient a feeling of security. No traction on the leg or splint is needed. This splint is left on for a varying period of time up to one week. The patient is encouraged to move about in bed and to sit up when eating.

After removal of the splint, the patient is turned onto his face twice every twenty-four hours for varying periods. A pillow support is used beneath the leg from knee to ankle and he may be lifted at once into



Fig 151

Fig 152

Fig 151—Fracture of neck of femur patient on fracture table but with incomplete reduction. Patient's arteries very sclerotic. The upper pin starting at distal end has to be withdrawn. Lateral view showed good replacement of head.

Fig 152—Anteroposterior view of hip in Figure 151 taken ten days after operation. This shows a still incomplete reduction in this plane. A final bony union was secured after long deferred weight bearing in spite of this inexcusably poor reduction. Proper reduction is the most important preliminary step.

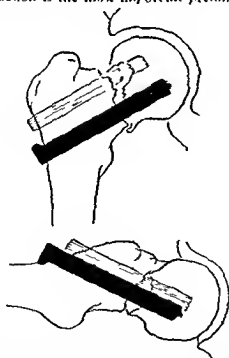


Fig 153—Diagrammatic illustration of King's suggestion to use both Smith-Petersen nail and autogenous bone graft one for firmness in fixation the other for possible additional fixation and osteogenetic powers (King Brit J Surg 76 721 (April) 1939)

a chair with a raised foot piece and may exercise the knee. No hip movements, especially flexion or abduction are allowed. Active muscle setting of the thigh muscles by the patient should be encouraged. Within two weeks the patient may stand on his good leg. Sometimes an extension sole is applied to the shoe of this good leg, and the use of crutches is taught. A roentgenologic examination should be made in two planes after the first and third weeks. No weight bearing on the nailed hip should be permitted until there is evidence of bony union and reestablishment of bony trabeculae across the fracture plane. This may take five or six months.

Intertrochanteric fracture does not require this internal fixation. For the most part this fracture may be treated by Russell traction with an effort at slight abduction and a push support on the bed under the well foot. The foot of the bed is elevated 6 to 8 inches. Some patients do better with reduction and body plaster of paris encasement. The Russell traction permits great freedom of motion of all the joints and generally pulls the fracture into complete reduction in four or five days. Seven pounds weight on the traction usually suffices (Fig. 158).

The long pointed or splir end of the trochanteric fragment of the femur in this fracture is thin and does not tolerate mechanical internal fixation well, nor will it hold against the stress of too early movement. An equal or better result from nonoperative treatment follows without the difficulties and risks of operation. There is ample blood supply and a large area of cancellous bone is exposed to induce callus formation and to afford every expectancy of union. As much movement and exercise of the patient can be obtained in Russell traction as by any other type of treatment.

OPERATION FOR DELAYED UNION OR NONUNION OF FRACTURE AT THE NECK OF THE FEMUR

Operation is indicated to alleviate pain, to attempt to restore bony union and consequently weight bearing and ambulation following lack of early diagnosis or efficient treatment to hold a proper reduction of the fracture of the neck of the femur confirmed by a ray film made in two planes. The percentage of such instances after fracture of the neck of the femur still remains surprisingly high. It will not be lessened until there is a higher grade of primary diagnosis and treatment of the fresh fracture.

A certain percentage of patients with nonunion who are seen within a year after fracture may be impossible surgical risks, but that proportion is diminishing rapidly. If a traction or plaster dressing has been applied, it must be removed to determine the condition of the skin over the fractured hip region. No operation may be attempted with open decubitus ulcers or local skin infections. Roentgenologic examination in two planes is required for the purpose of determining the

exact amount of absorption of the neck, the rise or rotation forward of the trochanteric fragment the rotation of the head and its state of viability as determined by its density in comparison with the surrounding osseous structures. If the head is completely dead with greatly increased density, an attempt to restore bony union may not be advisable. Complete removal of the head followed by a reconstruction of the hip or an ankylosis if the patient's age and condition war-



Fig 154



Fig 155

Fig 154—Roentgenogram of autopsy specimen recovered after pinning operation. Much of the neck had absorbed in this ununited fracture. No infection. The pins were well placed. The projection of the pin point was not great enough to enter acetabular surface.

Fig 155—Photograph of the specimen described in Figure 154. The projection of nail point is enhanced by loss of part of head in removal of specimen. The apposition of fragments, position of head and angle of nail insertion were all acceptable. This is the type of reduction fixation which should be sought in every instance. (Both illustrations from the author's textbook on Fractures and Dislocations 4th ed. Lea & Febiger Philadelphia.)

rant, may be the best procedure. Union to a dead bone may be obtained, but the reconstruction of the head by new bone formation requires a long period of time before weight bearing may be permitted. Consequently in the aged this process may not be worth the effort.

If an attempt at union is settled upon, manipulation of the hip to effect reduction is performed. The patient lies on the fracture table. Some traction on the injured leg may be required to hold the reduc-

tion I frequently use skeletal traction by means of a Steinmann pin through the calcaneus, firmly fixed to the foot piece of the table by strong wire attachments. The foot piece, still fixed to the patient's foot, may be removed from the table for extensive manipulations, and



Fig 156

Fig 157

Fig 156—Section of specimen recovered after infected operative attempt to nail fractured neck of femur. The lytic effect of the infection on the head fragment, the old dead portion (necrosis) of the head and the general invasion of the sepsis into hip joint structures can be seen. Track of the fixation agent not seen.

Fig 157—Specimen recovered nine months after infected fixation of hip fracture was attempted in Palestine. The Smith Petersen nail was copied but its insertion never touched the head. Resulting sepsis spreading through pelvis into opposite hip joint lead to death. Head completely dead. Absolutely no effort at bony union.

the degree of inward rotation of the foot can be accurately maintained.

Although it may be possible to obtain bony union after these non-unions by careful apposition with *nailing* or introduction of a bone

transplant, the percentage of successful results is not high. The aim of these attempts is to restore the normal anatomical angle of the neck of the femur, and in so doing the attempted union is often subjected to prolonged and often harmful stresses from the obliquity of the fracture plane. Union will not follow, for the normal weight-bearing stresses are not met in the mechanical readjustment. Some coxa vara results, with pain and frequently subsequent loss of bony support and



Fig. 158



Fig. 159.

Fig. 158—Example of the ordinary intertrochanteric fracture of the femur with impaction of head into trochanteric portion to which I called attention over thirty years ago. Note the thin, sharp fragment edge of the diaphyseal portion of the bone. This does not hold metallic fixation agents well.

Fig. 159—Same hip as Figure 158 four days later after patient (67 years old) had been put in Russell traction. Complete reduction—freedom of leg motion without disturbing reduction. Complete recovery in seven and one-half weeks. Why ever operate upon such a fracture?

hip joint changes. The time and immobilization required for these attempts make the effort prolonged, expensive and unfavorable for elderly patients.

Subtrochanteric Osteotomy.—This operation has much to offer patients with ununited fractures. It may be quickly performed and the subsequent splint confinement is not too long.

Technic.—Manipulative reduction is performed as for fresh fracture. The position of the fracture is checked by roentgenogram. The patient is placed on the fracture table with the legs in moderate abduction, employing skeletal traction on the heel of the injured leg if needed. A small incision $4\frac{1}{2}$ inches long on the lateral surface of

the thigh is made as for the nailing of fresh fracture, and the femur is exposed as for fresh fracture. The prominent point of the greater trochanter is identified and a second point selected on the shaft about 2 inches below this. Here a small steel pin is driven into the cortex as a marker. An anteroposterior film is made, and the point of insertion of this marker is determined in relationship to the neck of the femur and the lesser trochanter, at about which level the pin should lie. A high and slightly oblique upward transverse osteotomy of the shaft of the femur is then performed with a broad chisel and heavy hammer.

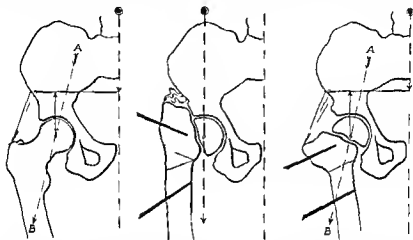


Fig 160—Schematic outline of Pauwel's method of cuneiform osteotomy to overcome ununited fracture neck of the femur. Note the normal weight bearing line from pelvis down neck of femur—passing along the strong trabeculae of the calcar femorale and close along the lower margin of the neck, where supporting pins nails or screws should be implanted. After ununited fracture of the neck this line of weight bearing falls inside the upper part of the femur. The bone cannot unite and meet the demands of weight bearing. Pauwel used two pins as shown inserted into the femur, cut out a wedge shaped piece of the bone between them, brought the pins forcibly together and thus brought the line A-B representing weight transmission back through the femur again. Not only does the osteotomy heal promptly but the ununited fracture of the neck restored to physiologic conditions and mechanics becomes bonily united. This is the basic reason for use of modern subtrochanteric osteotomy. (Hillebrand Bruns, Beitr z klin Chir 157 281 [March] 1933)

When the bone is cut through, the shaft usually tends to fall inward towards the pelvis, and the greater trochanter may rotate slightly outward. There is no interference with the muscle attachments to the great trochanteric area. If the shaft does not fall in easily, it is pushed either by a blunt instrument in the wound or pressure on the thigh by the surgeon. When well displaced inward, the foot of the broken limb is inspected to make sure that the great toe points straight up or is not externally rotated more than 5 degrees. The line is then

supported adequately by slings over pads in the popliteal area to an overhead bar to assure this position of inward displacement of the thigh and the straight up foot

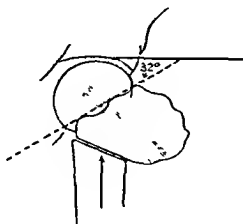


Fig 161—King's idea of the osteotomy for ununited fracture. Bone transplant inserted into head. high trochanteric osteotomy. The bone transplant is really not needed at all (King, Brit J Surg 26 721 [April] 1939)

To maintain this position an angled plate may be fastened to the end of a Smith Petersen nail which is driven up into the head of the femur as in fresh fracture. The shaft portion plate attachment is fastened by several screws to the lateral surface of the shaft of the bone. This takes some time and requires at least one additional set of roentgenograms.

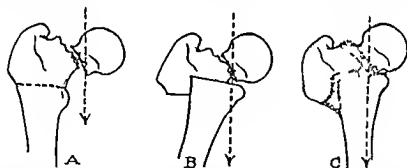


Fig 162—The present conception of subtrochanteric osteotomy. I prefer the high osteotomy and believe it should be more oblique upwards and inwards, than is shown in the diagram. In A is seen the changed weight bearing axis with its resumption to nearly normal as shown in C with healing of both osteotomy and of the ununited neck fracture in an average of eight weeks. (From the author's textbook on Fractures and Dislocations 4th ed. Lea & Febiger Philadelphia)

These internal splints are not essential. When the operator is assured by his direct vision and by an anteroposterior roentgenogram that the shaft of the bone has been shoved directly under the head fragment and is still maintaining contact with it, he may close the wound in layers, apply a small dressing and apply a plaster of paris body spica.

around the pelvis down the well thigh to the knee and down the fractured limb to the base of the toes, enclosing the Steinmann pin, if used, in the heel or tibia for maintenance of position

The plaster is properly trimmed around the genitals and buttocks. The patient may be turned safely in bed twice a day into a prone position, may partly sit up to eat, may move the unenclosed leg vigorously while lying prone and may be placed on a cart for outdoor sunshine exposure or transportation

Bony union practically always follows not only at the site of osteotomy, but also through the ununited neck of the femur. After eight weeks x-ray examination shows the progress, the plaster and nail in the heel are removed and the thigh and knee are gently massaged. Active movements are encouraged. Within seven to ten days the patient is able to sit on the edge of the bed and to start using crutches, not yet bearing weight on the operated-upon hip. The weight bearing follows two or three weeks after roentgenologic confirmation of progressing bony union. The patient should always wear shoes to support the relaxed feet

If a fixation plate and pin are used some surgeons believe that external immobilization is not required and that earlier motion of knee and hip may follow. While this may be so, it does not always ensue and the pin and plate may not retain the shifted displacement of the shaft of the femur or they may cause trouble as buried metallic fixation agents leading to death or cutting through of the head of the femur

The change of weight support directly under the head of the bone restores the natural lines and stimulates the bone to unite and to function in weight bearing. I have used osteotomy in patients up to ninety years of age and obtained bony union and subsequent ambulation (Fig 162). Osteotomy is usually a happy solution of the problem of nonunion at the neck of the femur

TECHNIC OF DÉBRIDEMENT OF THE KNEE JOINT FOR ARTHRITIS

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To the surgeon who has suffered and worried about surgery of joints, the technic of operation, up to the time the patient is placed on the operating table, is entirely secondary to the diagnosis. The knee joint is a complicated mechanism and, in order to approach it intelligently, the anatomy and mechanics as well as the pathology should be thoroughly understood. By reference to the work of Brantigan and Voshell^{1,2,3} one can refresh his memory and stimulate his imagination regarding the surgery of this intricate joint.

EXAMINATION AND DIFFERENTIAL DIAGNOSIS

The examination and differential diagnosis has as many facets as a complicated diagnosis anywhere in the abdomen, with fewer diagnostic aids except the surgeon's fingers and an intimate history gleaned from careful questioning of the patient.

Symptoms—Probably a "catch" accompanied by acute pain is the most frequent symptom which brings the patient to the doctor, and when one realizes that many conditions in the knee can cause this same outstanding symptom it is no mean feat to boil the diagnosis down to a definite conclusion.

Roughening or degeneration of cartilage beneath the patella or on one or both condyles will produce this symptom. A "joint mouse" or foreign body of any kind, a partial or complete tear of either lateral or medial meniscus, or a piece of cartilage slightly loosened on the articular surface of either condyle or on the head of the tibia, will also bring out the same complaint on the part of the patient. Disalignment in flexion or extension caused by a slight change in contour of one or the other condyle because of arthritic atrophy of cartilage, and disalignment of the line of pull from the quadriceps to the patellar tendon, allowing the patella to slip slightly lateral and ride up on the sharp edge of the anterior surface of the lateral condyle, are also causes of pain. Roughening and degeneration of the articular cartilage on the patella is one of the most frequent causes of crepitation and joint pain. Frequently the acute episode will be blamed on some slight trauma, but when one takes into consideration that that particular trauma has occurred many times in the patient's life and has never before given

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these symptoms the doctor should stop and wonder why on this particular occasion the symptoms developed suddenly. The catch may be accompanied by swelling or it may not; it may be accompanied by locking but frequently it is not. Therefore every structure in the knee joint must be tested at the time of examination to satisfy the mind that the symptoms are consistent with one or another diagnosis. It is impossible to cite the details of every diagnosis and the cause of symptoms in an article such as this but briefly we can sketch the usual technique of examination of a knee joint.

Tests for Joint Alignment—The patient should sit on the examining table with the knees bent at a right angle and the legs hanging free. The thighs should be uncovered as high as the hips so that alignment of the femurs with the tibiae can be clearly seen. The examiner then stands in front and asks the patient to put his legs as nearly parallel as possible and to bring them into full extension. Note is made as to whether the knees are in a position of valgus (knock knees) or varus (bow legs); whether the quadriceps tendon, the patella and the patellar tendon are in alignment or whether the patella has a tendency to pull toward the lateral or medial surface of the leg when the joint is in full extension. It is not infrequent with valgus position of the knees to have an unstable patella. It may never completely dislocate but it may pop up over the ridge of the external condyle or the external condyle may be abnormally flat and permit the patella to pull off laterally as the knee comes into the last 15 degrees of extension. If this is the case the knee is unstable and over a period of years this instability and constant cross strain and excess trauma may and frequently does produce traumatic or hypertrophic arthritis. As a matter of fact any cross strain applied to any joint many times over a long period of time will in most cases produce traumatic arthritis which may be the sole cause of disability simply because of often repeated slight trauma.

Tests for Integrity of the Lateral Ligaments—After the alignment of the joint is considered the examiner tests the integrity of the internal and external lateral ligaments. The internal ligament is tested by bringing the leg into *complete* extension, fixing the lower leg by grasping it at the ankle with one hand and forcing the other hand against the medial surface of the knee. If the lateral ligament is relaxed or weak or overstrained there will be a distinct give or bump which is signified by the joint separating between the outer condyle and the upper end of the tibia. If the ligament is tight as it should be there will be no give in this ligament or separation of the two joint surfaces. To test the integrity of the internal lateral ligament or collateral ligament the examiner's stool is moved to the other side of the member being examined with one hand the leg is again fixed in full extension and pressure is put on the lateral side of the knee toward the medial side. If the ligament is tight if no lateral motion occurs and

if there is no pain, it can be considered normal. If either of these ligaments is strained tenderness will be elicited at the point of strain even if there is no actual laceration. If the lateral cartilage is torn or frayed, and lying between the joint surfaces in such a way that it is pinched by this manipulation, pain may be elicited in the joint along the course of the cartilage.

In one case I was uncertain about the pinching of the meniscus causing pain and stripped the patient's knee in full extension and had him walk for an hour. In that short time the knee became swollen and the cartilage was so tender that the patient was in extreme pain, this in spite of the fact that he could extend the leg fully without any considerable pain at the time of examination. The next day we removed this cartilage and found it frayed, not at the anterior or posterior horn but about half way between the two, with fringes of the meniscus between the condyle and the head of the tibia.

Examination for a Loose or Torn Internal Semilunar Cartilage—In examination for a loose or torn internal semilunar cartilage especially if loose or torn at the anterior half, external rotation of the lower leg with the knee bent at a right angle, with mild pressure over the anterior part of the internal cartilage bringing the knee passively into full extension will often engage this cartilage and give acute pain even though there is no history of locking. Reversing this procedure does not always hold true in examination of an external semilunar cartilage injury, which is less frequent.

Test for a Ruptured Anterior Cruciate Ligament—This test is made by holding the foot between the examiner's knees, with the hand behind the calf of the leg, and the leg fixed at a right angle, the tibia is pulled forward at the upper end. If the ligament is torn there will be distinct forward slipping of the tibia on the condyles of the femur. With the leg straight the posterior cruciate ligament can be tested in the same way. A loose foreign body in the joint is characterized by a frequent change in the location of pain in the joint. The patient may call attention to the fact that it is sometimes on the medial surface, sometimes on the lateral surface. Maybe for a considerable time there will be no trouble then without any cause whatsoever, upon simple extension there will be a catch whether or not weight is being borne on the knee.

Blocking of Full Joint Extension—Many times when a patient is asked if he can fully straighten the knee after an attack of pain he will say yes, at the time of examination however, it is found that the leg may be lacking 5 degrees of full extension as compared with the other knee and when a little force is used to bring the affected knee into full extension there is a complaint of pain in the anterior part of the joint, either medially or laterally. This occurs as a result of slight blocking in the front of the joint, or from a partly torn or bucket-handle cartilage. It occurs not infrequently in arthritis involving the condyles

because of pressure put on the rough cartilage on the surface of the joint. If there is even slight locking between the internal condyle and the head of the tibia, pain is frequently elicited on the posterior surface or opposite diagonal probably due to stretching of the capsule posteriorly because of inability to bring the joint into full extension.

Detection of Patellar Cartilage Defect—Rough and broken cartilage under the patella can be detected by having the patient voluntarily flex and extend the knee while the examiner puts considerable pressure over the patella pushing it down toward the condyle. If this exaggerates crepitation and causes pain, one may be sure there is rough or degenerated cartilage on the articular surface of that patella grinding against the articular surface of the condyle. Many patients who have



Fig 163 Section of cartilage from surface of joint suffering from traumatic arthritis or hypertrophic arthritis. There is no difference in the appearance of microscopic sections. The cells stain poorly or not at all; nuclei in clumps; loss of columnar appearance and atrophy of matrix cells.

difficulty descending stairs suffer from this condition, it is extremely common in patients with slight deformity at or above or below the knees, in patients who are overweight, or in patients who have a tendency to arthritis but do not have exaggerated symptoms in other joints. The knee joint bears all the weight of the body at every step and the leverage put on the patella as it plays over the condyles in going downstairs especially, is tremendous. It is the last 15 degrees of extension while bearing weight that usually produces pain in most pathologic conditions of the knee.

Arthritis as Cause of Knee Joint Pain—In my experience the most frequent cause of pain in the knee in adults past the age of 35 is some form of arthritis, usually the degenerative type or so-called hyper

trophic arthritis Pathologically, looking at the cartilage only, whether from a joint in the spine, hip, knee or elsewhere, the sections show the same condition, a poorly staining cartilage with condensation of nuclei (Fig 163), with a columnar appearance of the cartilage entirely missing except for the nuclei which stand somewhat in clumps with their long axes in line between the matrix and the surface. This is true in the typical monarthritic joint which has been injured, or the hypertrophic joint which is one of many in the same individual. The cartilage looks the same in atrophic arthritis, but the symptoms are quite different. Atrophic arthritis is a constitutional disease with local joint manifestations, and should be treated as a constitutional disease. The patient should not be permitted to continue to traumatize the joints while treatment is proceeding.

DEBRIDEMENT OF THE ARTHRITIC KNEE JOINT

Traction—In my opinion neither atrophic nor hypertrophic joints should be immobilized by casts or splints. Traction allowing a certain amount of motion without weight bearing, and the free application of heat, will work much better than complete immobilization and will permit motion of the joint without damage. In other words rest is relative. Traction usually gives relief from pain. The patient can move about in bed and consequently, the muscles and ligaments controlling and supporting the affected joint do not become atrophied or rigid, nor does the circulation become indolent. Traction should not be of the type used to reduce a fracture of a long bone. The purpose for which it is applied is entirely different. For a fracture, the object of traction is to counterbalance the pull of muscles completely, thereby retaining the fractured fragments in position. In treatment of joints the object is to remove pressure from the joint surfaces and to give rest. Too heavy traction causes reaction in the ligaments and muscles controlling the joint and, personally, I never use more than 8 pounds of weight on the most robust individual in applying Buck's extension for treatment of pain and swelling or deformity in the knee. The traction should be applied to give pull in direct line with the articulating bones when in full extension in the case of hip, knee or spine. The patient may say he does not feel the pull. This is usually the case when extension is used properly. If kept on for twelve to twenty four hours a day, it has been my experience that not more than 8 pounds is the amount that gives the greatest comfort, and if it does not give comfort the amount should be reduced.

Indications for Debridement—The opinion has apparently been prevalent that little can be done surgically to relieve joints involved in an arthritic process. In my experience nothing could be further from the truth. We know that foreign bodies or broken or displaced menisci produce acute pain in joints. So far as I can judge, broken or rough

articular cartilage can produce the same pain. Experimental work⁴ has shown that often repeated slight trauma will cause the development of arthritis within the joint which sustains this trauma. One sees it frequently in old athletic injuries, many times years after the injury has been forgotten. It is commonly found in joints subject to cross-strain because of deformity, sometimes very slight, which causes strain to be put on a joint at an angle. It is one of the most common occurrences in hips after even a slight deformity from such conditions in youth as Perthes' disease or slipped epiphysis. A fractured or displaced meniscus, if unpaired, may cause exostoses and tremendous degeneration



Fig. 164—Hypertrophic arthritis patient aged 60. Note exostoses along the edge of the condyles, erosion and roughening of cartilage and widening of patella due to spur formation.

tion of cartilage in the knee. It is found in the knees of overweight women past the age of 40 more often than almost any other group (Fig. 164).

This localized arthritis, or hypertrophic arthritis which may be somewhat generalized, gives most symptoms in the joints where there is greatest strain. It is in this group that joint débridement gives the most satisfactory surgical results (Fig. 165). Certainly the earlier in the course of the trouble the rough and degenerated cartilage and exostoses can be removed, the better the result, but even in those cases in which the cartilage is rough and degenerated almost down to the bone on the weight-bearing surface, the results of surgery, when the proper operative and postoperative technic is followed, are among the most gratifying of any in joint surgery⁴ (Fig. 166).

Preoperative Care.—Preoperative technic involves a reduction in



Fig 165—Same joint as shown in Fig 164 with exostoses removed along the edge of the joint and condyles planed off. Note cartilage removed down to bare bone.



Fig 166—Same joint, with patella narrowed to show the amount of bone removed. These corners and sharp edges afterward trimmed off and rounded.

weight of patients who are much overweight. If the patient is not sufficiently interested in getting well to cooperate in this, he is not likely to cooperate in developing complete function in the knee after sur-

gery, and had best be left to worry along the best he can. If he is the type of patient who is looking for a pill to cure his pain without any effort on his part, the surgeon had better not take the case. In other words, careful selection of patients for surgery of joints has much to do with the results obtained. Early motion subsequent to operation is essential, and the patient who is not willing to go through the discomfort of early motion and help attain that motion, is not going to have a good functional result.

If there is contracture of the knee in some flexion, the patient should be put to bed with Huck's extension applied below the knee with up to 8 pounds of weight, for a sufficient time to bring the knee into full extension unless there is a foreign body actually blocking the joint in front. Of course it is impossible, in such a case, to straighten the knee until the foreign body is removed. In a case of traumatic arthritis where the joint has been held in 2 to 10 degrees of flexion because this is the position of least discomfort, the traction is applied as mentioned above, with the heel and ankle supported off the level of the mattress letting the knee sag back, this will often straighten the knee in two or three weeks. For the last few degrees of extension it may be necessary to put a sandbag or shotbag weighing 2 or 3 pounds on the anterior surface just over the patella. When this is done the position of rotation must be carefully observed, because there is a tendency to rotate the leg externally and let the lateral ligament accept the strain rather than the posterior capsule of the joint. A pillow is usually placed from the lower half of the leg to the heel, to form a gutter in which the lower leg and foot rest comfortably with the toes pointing straight to the ceiling. This is sometimes painful, and the patient must be given alternate flexion and extension for half an hour to an hour at a time.

When the knee has been brought completely into extension and the contracture in the flexor muscles and the posterior capsule of the joint has been overcome, surgery can be considered.

Draping—Preparation of the patient for surgery is not so simple in surgery of the extremities as in surgery of the abdomen or neck. Few surgeons have developed an adequate technic of draping the patient for surgery of the extremities, and unless draping is done properly, with the linen fixed firmly in position, contamination of the operative field can easily occur. The abdominal patient need not be moved on the table during operation, but the patient undergoing extremity surgery, especially joint surgery, must have the whole limb moved, sometimes frequently to permit access to various recesses in the joint. It is therefore highly important that draping be properly performed or supervised by someone who is aware of the possibilities and has the responsibility for meeting them. In our surgery of the extremities, no assistant, intern or resident is permitted to drape a patient until he has helped the surgeon do it many times and even then the operator super-

vices most cases. It is a nuisance, but careful supervision of details is necessary to successful surgery; therefore it must be accepted as part of the preoperative, operative, and postoperative regimen. Of course it is a foregone conclusion that surgery will not be performed in the presence of any sort of lesion on the skin surface, and that all infec-

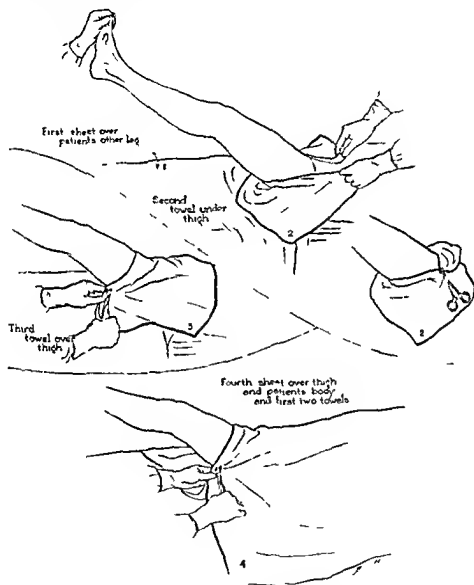


Fig 167—First stage of draping

tious processes have been eliminated before surgery is even contemplated. Shaving the leg must leave no abrasions, and it has been my experience that shaving the skin dry is much better than using soap and water; if it is done carefully there is no occasion for lacerating the skin.

A thorough twenty minute soap and water scrubbing is given twenty four hours preoperatively, followed by sterile protection without the use of an antiseptic. When the patient is on the operating table there is another fifteen minute scrub with soap and sterile water over a wide area. The skin is then dried with ether, using care that no ether runs down onto the table, where it will come in contact with and

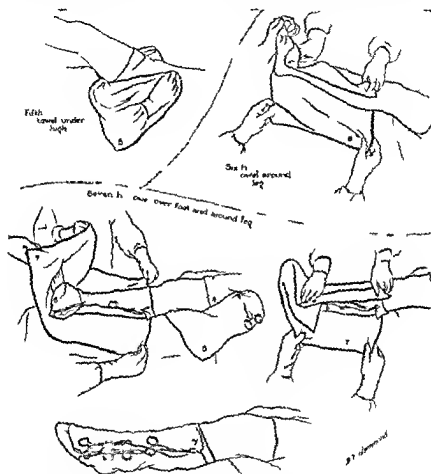


Fig. 168—Second stage of draping

blister the skin. This is followed by washing with uncture zephiran more particularly, because it is colored and one can be sure the entire surface has been thoroughly covered. The leg is then held high in the air with the knee straight, the nurse grasping the foot—and a tall nurse is to be preferred for this. The leg is held sideways off the table with the hip in abduction (Fig. 167). The lower sheet is placed under the thigh and leg, covering the table and the other leg. A towel is brought

under the thigh, brought together in front and clamped with a towel clip to the skin. Another large towel is brought from front to back high on the thigh, and clamped to the skin in back. The upper sheet is then placed across the body, looped below these towels, and clamped beneath the thigh. This point of clamping is then covered with another towel brought beneath the thigh and clamped anteriorly. Thus the upper part of the thigh and the body are completely walled off, with the linen firmly fixed to the skin so that there can be no possible contamination from above. While the nurse still holds the

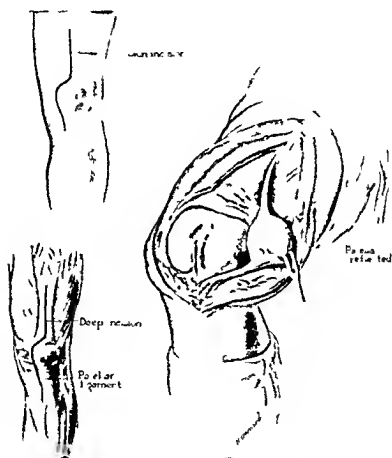


Fig. 169—Incision for approach to knee joint

foot, a single towel is carefully wrapped around the lower leg below the knee, the upper edge coming 2 inches below the head of the tibia (Fig. 168). A towel is then laid lengthwise over the sterile sheet, and the foot and leg are lowered onto it, the lower end of the towel being brought over the toes to the dorsum of the foot and the sides of the towel wrapped around the leg. The entire leg is then covered with another towel or a stocking. The exposed surface of the skin is then given a second application of alcoholic zephiran.

Technic of Debridement—We use the parapatellar incision most fre-

quently in the approach to the knee joint (Fig 169) It is started below at the medial edge and lower end of the patellar tendon, extends upward toward the medial half of the patella, skirts the patella and crosses the quadriceps tendon to its median line, and extends up the median line of the quadriceps about three or four inches No tourniquet is used, bleeders are clamped and tied as they are uncovered Tendinous attachments and fascial attachments to the sides of the patella are cut, leaving enough attachment on the patella for suture The medial half of the quadriceps tendon is cut at a right angle to its long axis near its attachment to the patella and the incision is con-



Fig 170 Hypertrophic arthritis of knee with removed degeneration of cartilage in localized areas under the patella and in the intercondylar spaces between the patella

tinued up through the quadriceps to as high a point as is necessary, usually close to the musculotendinous junction The synovia is incised, usually along the medial edge of the patella, and when the joint is opened the incision is followed down to its lower end In the lower third considerable bleeding is sometimes encountered, especially at the fat pad which cannot always be pushed lateralward A sharp hook retractor is placed at the medial surface of the patella and the patella is turned outward and upside down As the knee is bent approaching an angle of 90 degrees of flexion or more, the patella lies with the articular surface facing upward and outward, outside the lateral condyle The muscles and fascia attached to the inner side of the incision can

be reflected medially. The incision must be long enough so that the joint can be opened wide and completely exposed from one side of the condyles to the other.

The patient's foot now rests with the sole on the operating table, the knee bent to usually more than 90 degrees, the condyles completely exposed. The menisci can be examined for tears or degenerative processes and should be removed if not normal. Erosions will be seen around the edges of the inner and outer condyle. The cartilage of the joint is usually a little yellowish and more or less granular on the surface, with areas of erosion or degeneration scattered usually in the location which bears the most weight and receives the most trauma in normal use. In my experience the articular surface of the patella



Fig 171 - Removal of exostoses from one side of joint held in place by forceps to illustrate amount of exostoses removed

usually shows the greatest degeneration (Fig 170) next the weight-bearing surface of the internal condyle, and that of the external condyle third. These areas of degeneration correspond to the site of greatest strain on the various parts of the knee. The patella always bears the greatest strain because it is involved in the application of power from the quadriceps to the weight, which it moves at its attachment on the tibia. Most people are slightly bowlegged, and in individuals who are inclined to have the knees in varus positions, the greatest amount of weight falls on the internal condyles. However, in valgus position it will be found that the greatest amount of degeneration is on the weight bearing surface of the external condyles.

The object of surgery is to remove all irritating material from the

joint, because it is this roughness that continues the irritation and its removal apparently allows the joint to regenerate new and healthy cartilage if there is sufficient healthy matrix remaining. If this is true it is quite apparent that operation should be performed before the degeneration of cartilage has reached the stage where no matrix remains. Good results are in direct ratio to the amount of normal matrix which will regenerate normal cartilage cells after surgery. It will be noted that the articular surface of the upper end of the tibia is usually much less involved in this degeneration of cartilage than is the articular surface of the lower end of the femur. The same is true in the hip, with regard to degeneration of cartilage on the femur as compared with the acetabulum.

The exostoses found around the edges of the condyles are completely removed (Fig. 171) along the edge of the synovia and over the edge of the cartilaginous surface of the joint. This is done with a very sharp, very thin bladed chisel, usually there is very little trouble some bleeding. During this procedure the joint is constantly moistened with normal saline, all parts which are not under immediate surgery are covered by sponges sopping wet with normal saline solution. Car become dry, any more than the ssential part of operative proce oint surfaces exposed a more or less constant drip of saline solution is applied.

After the exostoses have been removed from the edges of both sides and above the condyles the cartilage surface is shaved with a very sharp scalpel. All degenerated cartilage is removed even if it is necessary to take it down to bare and bleeding bone in some areas. Nothing is left except the shiny hyaline cartilage. This may appear to be an extremely radical procedure because when one is through frequently there are few spots of normal hyaline cartilage remaining. The shaving is done with either a very sharp razor blade chisel or a scalpel in such a way as to leave whatever ridges there may be on the surface of the joint running parallel to the line of motion of the tibia on the femur. If these ridges are left across the line of motion the surface of the femur is like a washboard if turned in the opposite direction these little ridges act as tracks and still allow smooth motion. If the bone is eburnated the hard surface is chiseled off until it bleeds unless it is removed it will always remain in a state of eburnation. If the outer shell is chiseled off carefully granulations can form to act as a covering of fibrocartilage on the surface. This fibrocartilage apparently acts as a gliding membrane on which the joint moves very well corresponding to the fibrocartilage on the ends of the fragments in an old ununited fracture. If early motion is started this surface does not become adherent to the upper end of the tibia and the fibrocartilage seems to function perfectly and allow free and painless motion in the joint.

When the condyles have been thoroughly and carefully planed they are covered with very wet sponges and the patella is considered. Here the cartilage is usually much thicker and much more degenerated and large sharp exostoses are found along the edges, which materially widen the bone. These edges are completely removed so that the patella is reestablished to normal size and shape, or even made smaller, and the rough and degenerated cartilage is shaved off in the same manner as in the condyles (see Figs 164 and 165). There are usually a sufficient number of islands of cartilage left to act as a skidway be-



Fig 172—Complete debridement. Note large excision of degenerated cartilage from articular surface of patella and on anterior surface of condyles immediately under the patella. Note removal of surface cartilage on the internal condyle down to the bone with areas of normal hyaline cartilage between

tween the patella and the condyles, allowing the patella to move freely over the condyles without pain or irritation. If any ridges are left here they should be longitudinal, not transverse. We have not found it necessary to remove the patella in these cases. In my opinion it weakens the knee and in more than 100 operations for knee debridement there have been no cases where it did not work properly between the quadriceps and the patellar tendon. It cannot be emphasized too much that all diseased, broken and rough cartilage should be removed, even down to bare and bleeding bone, and this should be thorough.

When the operation is completed (Fig 172), the joint is washed.

out with normal saline solution, using a syringe, and is thoroughly inspected to see that no loose pieces of cartilage or bone and no unhealthy cartilage remains.

In about 20 per cent of our cases we have found a rather sharp spike of bone at the anterior tibial margin, which abuts against the front of one or the other condyle when the knee is in full extension. We have removed this spike down to the level of the tibial plateau because in most cases it actually impinges against the condyle and acts as an irritant to the joint.

Sutures and Dressings—The synovia is sutured with the synovial surfaces in what Murphy used to call ectropion, so that they are in contact, with no cut surface within the joint. For this and for all other sutures beneath the skin, double-0 plain catgut is used, except where the cut end of the quadriceps tendon is resutured, and here two interrupted No. 0 chromotized catgut sutures are used. The dressings are held in place by an ace or tetra bandage, no gauze bandage is used. Over the first bandage are placed two ABD pads in front and two in back of the knee, bandaged on with considerable pressure with an ace or tetra bandage, then the entire leg is bandaged from toes to thigh with some elastic form of bandage.

Postoperative Care—When the patient is returned to bed a pillow is placed lengthwise under the thigh and leg and the leg is placed into the gutter formed by the pillow, to avoid its rolling from side to side. Narcotics are used freely for the first two or three days.

The third day following operation the outer bandages are removed and the leg is completely straightened by moving the pillow down to the ankle and foot, not permitting any support under the knee. This can be borne only for fifteen minutes to half an hour at a time. Then the leg is allowed to rest on the bed, but the position is changed at least four times a day, the knee being brought into 10 or 15 degrees of flexion and then again into full extension. On the third day the patient is given thorough instruction in exercise of the quadriceps and it is sometimes difficult to make him understand that the quadriceps can be exercised without actually moving the knee. This is extremely important because without power in the quadriceps the patient will not be able to get out of bed and walk on the eighth or tenth day. On the fourth day a sling is placed under the knee, this is attached to an overhead pulley by a rope with a handle so that the patient can exercise the knee by lifting it from the bed and letting the foot down, then straightening the leg with support under the knee. At first this is somewhat painful, but it is surprising to see how much early motion can be developed if the patient is persistently encouraged and instructed. On the fourth day all bandages are removed except the one holding the dressing, and on the sixth day this bandage is removed. The dressing is held by transverse adhesive plaster strips, so that nothing binds the knee and prevents flexion. From

now on motion should come rapidly, and by the eighth day the patient should have 45 to 60 degrees of voluntary motion with complete control of the quadriceps

Lessons in Walking—On the eighth to tenth day, depending on the age and weight of the patient, he is requested to get out of bed with no help except that afforded by the operating surgeon holding the leg by the heel to avoid sudden jolts. When the patient reaches an almost upright position the leg is lowered to the ground and the first lesson in walking starts. It is extremely important that the surgeon take charge of the first few lessons. This cannot be delegated to an assistant or associate, because the patient has little confidence that he will be able to walk, and needs all possible reassurance, thus he can get only from his doctor. When standing at the side of the bed, the patient at first will have the knee and hip slightly bent and will be in a slightly stooped position because he is afraid the knee is going to give him pain, and it will if he is allowed to bear weight in any degree of flexion. The pain is caused by tightening of the sore tissue where the incision was made. There will be no pain if the weight is borne straight on the knee when it is in full extended position. Therefore the command is given—'Knees straight, tail in, chest up, head up!'

Patients are never given crutches to aid in walking. Every patient I have seen with crutches stoops forward and leans on them, and is very apt to bend the knees and hips in this position. The surgeon stands back of the patient, the patient's elbows bent and the surgeon's hands placed firmly under the elbows with the upper arm straight down. A little swaying from side to side in this position will give the patient confidence that he will not have pain when he bears weight on the knee. Then the affected leg should be advanced first, the surgeon's own leg going forward with it, just a little to the side with the toes turned out. Weight is transferred from the unaffected leg to the affected leg when, and only when the hip and knee are straight and the patient is standing with chest up and head up. The first step will not cause pain, and when the patient finds he can bear weight on the affected leg without pain he takes the next step normally. Six or eight steps for the first lesson is enough to give him confidence. Usually three or four lessons will serve to persuade him he can walk without help. Then he is given a pair of heavy canes sawed off to the length most easy for him to use. The canes should be an inch and a half longer than the distance from the palms to the floor, when the arms are held flat at the sides perpendicularly. Most patients tend to hold the handle of the cane away from the body. This is bad, because the canes wobble between the shoulder and the floor. The hands should be held against the sides of the thighs with the arms straight, the canes pointed downward and outward from each thigh. The cane thus makes a brace between the thigh and the floor. If held in this way, the canes can be moved by simple motion of the wrist without

any motion of the arms. They should be moved synchronously with movement of the operated leg.

These may seem like petty details, but we have found by much experience with surgery of the knee that early weight-bearing and painless walking can be attained only by attention to just these annoying petty details. The after-care in these cases is as important as the operative procedure, and good results cannot be expected unless all the details are followed closely and supervised by the surgeon.

SUMMARY

We have now performed more than 100 debridements of the knee, and many of these patients have left the hospital walking without a limp in less than three weeks. If cases for this operation are properly selected, and operative technique and after-treatment are carefully adhered to, the results of debridement for traumatic or hypertrophic arthritis of the knee and hip are among the most satisfactory in any form of joint surgery.

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THE SURGICAL CLINICS of NORTH AMERICA

NEW YORK NUMBER

SYMPOSIUM ON SURGICAL DIAGNOSIS

FOREWORD

Accurate surgical diagnosis continues to remain one of the great problems in the teaching of medical students, interns and surgeons generally throughout the country. Unfortunately in many instances the physician has been relied upon to make the diagnosis and the surgeon has served only as a "mechanic."

It is my own belief that the responsibility for the proper diagnosis rests squarely on the shoulders of the individual who operates upon a patient, if unnecessary and unwise operations are to be avoided. Furthermore, the information gained through a thorough diagnostic study is of inestimable value in determining the extent and character of the operative procedure. I am not advocating that the findings of the attending physician be disregarded, on the other hand, they can and do carry great weight with the conscientious surgeon. In addition, the physician can be a tremendous help in the pre- and postoperative periods in seeing that the laboratory tests are properly carried out and that suitable therapeutic measures are undertaken.

The present symposium, presenting some of the more common problems of surgical diagnosis, is offered principally by surgeons of the New York area. Included, however, are significant papers from the Montreal General Hospital McGill University group, and from surgeons in the Services. During the past four years great contributions in war surgery have been added to the literature and it is hoped that many things have been learned out of these experiences that will be applicable to the surgical care of peacetime injuries and diseases.

HENRY CAYE

Consulting Editor

DIFFERENTIAL DIAGNOSIS BETWEEN RUPTURED LUMBAR INTERVERTEBRAL DISK AND CERTAIN DISEASES OF THE SPINAL AND PERIPHERAL NERVOUS SYSTEMS

BRONSON S RAY, MD *

THE recognition of the syndrome of the ruptured lumbar disk has given rise to much debate in the past ten years and at times to strong differences of opinion. But it can be said without danger of contradiction that the orthopedic surgeons and the neurosurgeons, the two groups who have been most occupied in dealing with backache and sciatica, have become more aware of each others' problems. While there are many common causes for lower backache, by far the most common cause of the group of symptoms broadly referred to as "sciatica" is ruptured lumbar intervertebral disk. However, there are a number of other conditions that occasionally may simulate the syndrome of the ruptured disk and constant vigilance is required to avoid mistakes in diagnosis.

This discussion does not include a consideration of other musculo-skeletal defects that are problems purely for the orthopedic surgeon but deals rather with neurological diseases that have in my experience simulated exactly or in part the clinical picture that might be expected to result from a ruptured lumbar disk.

THE CLINICAL PICTURE IN RUPTURED LUMBAR INTERVERTEBRAL DISK

The syndrome of the ruptured lumbar disk is well established and the diagnosis can be made with a high degree of accuracy on the basis of history and physical findings when they are typical. Typical symptoms and signs include the following:

- 1 Pain in the lower back beginning acutely following some occupation or event capable of producing undue stress on the back
- 2 Subsequent extension of the pain from the back down the posterior or posterolateral aspect of one lower extremity at least as far as the ankle
- 3 Increased pain on coughing and other forms of exertion
- 4 Numbness and other paresthesias in the painful extremity
- 5 Scoliosis, loss of the normal lordosis, and limitation of motion in the lower back
- 6 Positive Lasague's sign in the painful extremity

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7. Impaired knee or ankle reflex in the painful extremity
8. Impaired sensation in the lower lumbar and upper sacral dermatomes in the painful extremity.

Other findings may be brought out in many cases where there is only the history of radiating pain and a positive Laségue's sign from which to draw conclusions. If we were not called upon to make diagnoses in other than those with the typical syndrome the percentage of error would be less and the results of treatment would be much better.

DISEASES OF THE SPINAL AND PERIPHERAL NERVOUS SYSTEMS, SIMULATING RUPTURED LUMBAR DISK CLINICALLY

Of the diseases of the spinal and peripheral nervous system which may cause a clinical picture much like that of a ruptured disk, some are surgical and others are not. It is obviously better to discover or suspect such disease before rather than after operation is performed for a presumed ruptured disk. At least one should try to develop some conviction beforehand about the desirability of more extensive exploration if at operation he finds no protruding nucleus pulposus to account for the clinical findings.

In a review of my own experience in the past five years, during which time I have operated upon more than 250 patients for ruptured lumbar disk, I have listed some of the neurological conditions encountered during this period which simulated ruptured lumbar disk in the symptoms and signs they produced. In these conditions it was difficult or impossible for me or others to arrive at a correct diagnosis before the final evidence was obtained. The list is not designed to represent an all-inclusive table of the diseases that might be confused with ruptured disk but will serve to bring to attention the kind of things for which one must be on the alert.

CLASSIFICATION OF NEUROLOGICAL CONDITIONS SIMULATING RUPTURED LUMBAR DISK IN THE CLINICAL PICTURE PRODUCED

A. Intradural tumors

- Neurofibromas (neurinomas)*—7 cases
- Ependymomas—3 cases
- Meningiomas*—1 case
- Teratomas—3 cases
- Spinal varices—2 cases

B. Radiculitis

- Idiopathic radiculitis
- Herpes zoster
- Localized leptomeningitis
 - a. After spinal anesthesia
 - b. Infectious (syphilitic)
 - c. Noninfectious (cholesteatoma)
- Guillain-Barré syndrome
- Syringomyelia

* These may occur intradurally or extradurally.

ependymomas and *meningiomas* are quite comparable in their effects and operability to the *neurinomas*

Teratomas (and *dermoids*) usually involve the *conus medullaris* of the cord and, though they are congenital tumors, they often do not cause symptoms until later life. They produce dissociation of sensation particularly in the saddle area, but these changes may readily be overlooked unless diligently sought for. In one of the three cases in this review, the effects of the tumor were largely on the roots of one side, and the predominant symptom was pain radiating down the posterior thigh and leg of that side.

Varicosities of the spinal vessels occur most often in the lumbosacral cord and *cauda equina* though they occur at other levels of the cord as well. The condition is probably a congenital anomaly but almost never gives evidence of its presence under twenty years. True spinal varices are intradural and subarachnoid and are not to be confused with large epidural veins that are present in the region of a protruding disk and, incidentally, which prove so exasperating when torn at the operating table. In a collected group of these cases, it was found that the first symptom is usually pain in the back or one extremity. The onset of pain is usually acute and frequently related to trauma. The pain has the character of radicular pain, is less when the patient is recumbent, and is made worse by coughing and straining. Disturbances in power and sensation in one or both lower limbs follow the onset of pain. But there may be a series of remissions and exacerbations until finally marked sensory and motor disturbances develop in the limbs and loss of bladder function occurs. The following case is illustrative.

CASE III—A 43 year old man, two years before admission to the hospital felt a sudden pain in his lower back while lifting machinery. Severe pain in one lower limb followed and he was confined to bed for ten days after which he recovered completely. Six months later on jumping down from a platform the pain in the back and one limb recurred and incapacitated him for work thereafter. Weakness developed in the painful limb and he was treated by a succession of doctors for sciatica. The sudden development of urinary retention resulted in his admission to the hospital. The neurologic findings indicated involvement of several roots of the *cauda equina* chiefly on one side. The spinal fluid protein was 100 mg per 100 cc. At operation a spectacular nest of varices was found over the lower end of the cord and upper portion of the *cauda equina*. The lesion was of course inoperable. The sequel to the story emphasizes the similarity of the symptoms to those of ruptured disk because six months after the operation another surgeon dissatisfied with the diagnosis explored the patient for a ruptured disk and found none.

Careful attention to the nature of the pain will sometimes give a clue to the presence of tumor. Pain resulting from irritation of nerve roots by neoplasm is likely to be more excruciating and dramatic in its effects than that from protruding disk. Also, while patients with disks find lying in bed uncomfortable only at first, and comfort to be

largely a matter of assuming the right position, patients with tumors may find lying in bed intolerable

Probably the most significant difference between cases of protruding disk and intradural neoplasm that simulate each other clinically is in the spinal fluid. I do not recommend or employ routine lumbar puncture, but if there is the slightest room for doubt in the diagnosis, the examination must not be omitted. In my experience, less than 10 per cent of cases of proven protrusion of the disk have a spinal fluid protein content of over 75 mg per 100 cc, whereas it is the rare tumor case that has less than 100 mg per 100 cc. In case of a high spinal fluid protein, or any evidence of obstruction of the spinal canal by the Queckenstedt test, a spinogram should be employed. I do not advocate routine spinography, although pantopaque can now be obtained for civil use and is a satisfactory contrast medium in that it casts a good shadow and can be removed through a needle or left to absorb.

Radiculitis—There are various forms of radiculitis to be considered in differential diagnosis with ruptured disk. One might be less impressed with this were it not for the fact that hardly a week goes by that the need for differential diagnosis does not come to attention.

Herpes zoster is a good example of acute localized radiculitis. To be sure, the herpetic eruption is the result of the effect of the disease upon the posterior root ganglia, but there is good reason to believe that the sensory root—occasionally even the motor root—is involved by the disease. In all probability the same disease sometimes affects roots without affecting the ganglia, and then the tell tale eruption is missing. The disease runs its acute course in six weeks, and this suggests that six weeks might be a good minimum time to allow before considering exploration for a ruptured disk.

Under the heading of *localized leptomeningitis* are included cases in three categories: (1) postspinal anesthesia, (2) infectious (syphilitic), and (3) noninfectious.

The possibility that spinal anesthesia is occasionally followed by a low grade, long persistent though usually nonprogressive radiculitis of the cauda equina, cannot be ignored. In the past eight years I have explored three patients in whom I finally concluded the lesion could be ascribed to or was at least initiated by spinal anesthesia. In one of these the symptoms and signs were such that I was led to explore for a possible ruptured lumbar disk before proceeding with the intradural investigation.

The following case is an example of localized infectious meningitis simulating ruptured disk.

CASE IV—The patient was a 41 year old laborer who a year before admission to the hospital developed radiating pain from the left lumbosacral region down the posterior thigh and calf to the ankle and foot together with slight weakness in this limb. The pain and weakness persisted in varying degree until one month

before admission to hospital
also in less
sation on the
atrophy of

lower lumbar and upper sacral dermatomes. The spinal fluid showed 100 polymorphonuclear leukocytes, a positive Pandy test and (unaccountably in view of later findings) a negative Wassermann reaction. A spinogram revealed a filling defect at the level of the second lumbar vertebra. At operation the lesion was found to be a gumma involving the roots of the cauda equina largely on the left. Until this time the case had been considered a compensation case.

An example of noninfectious localized meningitis was that of a man in whom pain in the lower extremities and absent ankle jerks appeared shortly after removal of a cholesteatoma from the posterior cranial fossa. Some of the cholesterol known to be irritating was accidentally lost in the subarachnoid space and undoubtedly gravitated to the caudal end of the meningeal sac causing an inflammatory reaction of the roots of the cauda equina. Because of the persistence and fluctuation of the symptoms from side to side an exploratory operation was performed which revealed normal disks but edematous and inflamed nerve roots. A number of months passed before recovery occurred.

The *Guillain Barre syndrome* is a relatively new and altiloquent name for what has been variously recognized in the past as infectious polyneuritis, infectious neuronitis, polyradiculoneuritis, radiculomyelitis, Landry's paralysis and others. These terms imply an acute disease that affects nerves, nerve roots and cord. There are varying degrees and extents of the disease and usually it runs a course over months ending in partial or complete recovery, rarely in death. The initial symptoms are nearly always in the lower extremities and include pain, paresthesias and weakness. Pain in the extremities is often the chief symptom at first and may be accompanied by lower back pain. The effects are bilateral but may predominate on one side. The upward extent of the disease is variable and until or unless the full blown picture develops diagnosis may be problematic. The spinal fluid shows characteristically an elevation of the total protein and no increase in cells. A fair number of patients with this disease have been referred in recent years with a preliminary diagnosis of ruptured disk and a few have been explored surgically though usually to look for a cauda equina tumor.

Syringomyelia is included in this discussion because of a few cases in which differentiation from ruptured lumbar disk was required. Syringomyelia has the faculty of producing bizarre symptoms and this is not the place to review all the vagaries of the disease. In one case it caused over a period of several years, recurring pain in the lower back radiating into one or both lower extremities. The reflexes in the lower limbs were diminished or absent and there was spotty sensory loss. The diagnosis was made on the basis of dissociation of

sensation and a weak Babinski sign on one side, later, additional signs appeared in the upper extremities

Intraspinal Extradural Tumors—In the intraspinal extradural space a number of other lesions can exist besides protruding disks. The benign encapsulated *meningiomas* and *neurofibromas* listed previously as intradural tumors may also occur here. The latter tumor is particularly prone to possess a dumb bell shape due to an intraspinal and extraspinal expansion connected by a narrow cylinder of tumor incorporating the nerve in the intervertebral foramen. The presence of a tumor of this kind can often be detected by roentgenographic evidence of erosion of adjacent vertebral pedicles and widening of the interpedicular spaces. In fact, any of the extradural tumors particularly *metastatic tumors*, may be expected to show roentgenographic changes in the vertebra with a high degree of frequency. On the other hand, roentgenographic identification of ruptured intervertebral disk by plain films without the use of contrast media has been unreliable and misleading. Roentgenograms of the spine in suspected rupture of the intervertebral disk have their greatest usefulness in differential diagnosis from other diseases.

Chordomas are tumors of notochordal origin which occur characteristically in the lumbosacral region and usually cause radicular pain. They are of low grade malignancy and tend to invade bone. In the several such tumors of my experience, the diagnosis has been suspected on the basis of roentgenographic changes in the vertebrae. However, there are records of at least two cases in which other surgeons have encountered small unsuspected chordomas when exploring for a protruding disk in the lumbar region.

Lymphosarcoma occurring as a localized tumor in the spinal epidural space and without evidence of accompanying generalized systemic lymphosarcomatosis is not rare. In our clinic it comprised 4 per cent of primary tumors occurring in or about the cord and cauda equina.

CASE V—One of the cases was that of a 55 year old woman whose complaint was low backache and pain down the back of both the lower limbs to the feet of eight months duration. For the first three months the pain had been exclusively in one limb and was consistently made worse on coughing. By the time of admission to the hospital the symptoms and signs were plainly bilateral there was urinary difficulty and the spinal fluid protein was 200 mg per 100 cc. The tumor was found at operation to comprise a thin cuff about the dura from the fourth lumbar to the second sacral vertebra. Partial removal decompression laminectomy, and x ray therapy have already given her five years of complete freedom from symptoms.

An extraordinary case is one in which sciatica was found to be due to a *dural cyst*.

CASE VI—A 43 year old woman during seven months had had three episodes of sudden pain in the lower back extending down the posterior aspect of the

right lower limb to the ankle. Each attack began with lifting or bending and confined her to bed for six to ten days. There was a positive Laségue's sign, absent ankle jerk, and unpaired sensation in the first sacral dermatome on the right. The spinal fluid was normal. At operation a dural cyst was found presenting in the right lumbosacral interspace. When more fully exposed, it was found to fill much of the sacral canal and to arise from a small stalk at the end of the spinal dural sac. The cyst contained clear fluid but the cavity did not appear to be connected with the subarachnoid space. Its excision has resulted in complete relief for three and one half years.

The diagnosis of *hypertrophied ligamentum flavum* as a cause of sciatica has had its day of popularity but hardly deserves perpetuation. The ligamentum flavum together with a protruding disk or an other wise narrow channel for the nerve roots contributes to the syndrome, but there does not appear to be adequate evidence for assuming that more than rarely is the ligament actually hypertrophied to a degree sufficient to cause symptoms in the absence of other local pathology. But one case, in this series, has been considered to fulfill the requirements for the diagnosis of hypertrophied ligamentum flavum.

CASE VII.—A 42 year old mail carrier had toted a 40-pound sack fifteen miles a day for many years. For four years he had attacks of a burning shooting pain spreading from the buttocks down the posterior part of the lower limbs to the feet, more marked on the right side. The sensation appeared twenty to thirty minutes after steady walking and climbing steps, and was relieved by five to ten minutes of rest. The right ankle jerk was absent and the left greatly diminished, there were no definite sensory changes. Spinal fluid was normal. A spinogram showed a marked filling defect at the fourth lumbar interspace, and at operation it was found that the ligamentum flavum here greatly narrowed the spinal canal. The disk appeared normal. Removal of the ligament has resulted in complete alleviation of his complaints for five years and he continues at the same work.

Extraspinal Nerve Lesions.—Extraspinal nerve lesions are not usually thought to require differentiation from intraspinal lesions since it is assumed that the former should be discovered in most cases in the course of complete examination. Yet periodically cases come to attention in which the diagnosis of sciatica due to ruptured disk has been persisted in for weeks and months without the true nature of the condition being recognized. A variety of neoplastic growths in the pelvis may compress or invade the sacral plexus producing radiating pain and neurologic changes in the lower limb. In some, the symptoms and signs may for a while be indistinguishable from those of protruding disk, but on the whole, the pain is sooner or later more diffuse, persistent and excruciating than occurs in the average patient with protruding disk. That the diagnosis may occasionally be difficult is supported by the following case.

CASE VIII.—A young physician had pain extending down one lower limb for three years. The distribution of the pain was in the buttock, posterior thigh and calf, but also in the groin and inner thigh. There were no remissions of the pain and it was enhanced by certain movements of the limb but not by coughing and

straining. The ankle jerk was absent, and there was slight sensory loss over the outer malleolus. He at first had a negative exploration for a protruded disk, and next a lumbosacral spine fusion without relief. Another exploration for ruptured disk had been advised but abandoned when a pelvic tumor, probably of osteogenic origin, was discovered and was undoubtedly the cause of his symptoms from the start.

Most peripheral nerve lesions do not give trouble in diagnosis but two selected cases will demonstrate how mistakes may be made. One case is that of a young woman with several years' history of sciatic pain thought to be due to a ruptured disk and treated unsuccessfully by physiotherapy, back brace and local injections. Her pain was ultimately found to be due to a fibrolipoma which compressed the sciatic nerve at the sciatic notch. Relief followed removal of the tumor. Another case is that of a slender, asthenic type man of poor posture with many years' history of backache who developed a partial peroneal nerve palsy after lying in bed for some weeks with a bleeding peptic ulcer. His physician, long harassed by the patient's complaint of backache, now finding impaired sensation over the foot and weakness of the ankle, too readily concluded that a ruptured disk was the cause of both conditions.

SUMMARY

In conclusion it is emphasized that the clinical pattern produced by the ruptured lumbar disk is fairly consistent. There are a number of other diseases, particularly of the spinal and peripheral nervous systems, which may partly simulate, and a few that may exactly simulate, in their effects the sciatic syndrome produced by a ruptured lumbar disk. But on the whole, these other conditions can be recognized by giving proper care to clinical evaluation of symptoms and signs and by employing such laboratory tests as are useful. At best, some patients will still require exploratory operation for final diagnosis. At time of operation, the surgeon must determine how far he is required to search and be prepared to deal with whatever lesion presents itself.

THE DIAGNOSIS OF LESIONS OF THE MEDIASTINA

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In the philosophy of diagnosis it is evident that one or more of several different methods may be employed. It is often possible, and it is the system used by many physicians and surgeons, to enumerate the various signs and symptoms presented by the patient and by a method of syllogism to establish the diagnosis as it were by an equation method. Others employ a technic whereby the essential symptom is decided upon and, with this as a starting point, an attempt is made to prove the diagnosis. As an example of this method, if among the patient's complaints is included that of the presence of Horner's syndrome, whatever diagnosis is eventually established must be one which will explain this essential symptom. A third method of arriving at a diagnosis is to list all the possible lesions which might account for the signs or symptoms noted in the patient and by a method of exclusion reach the probable diagnosis.

In the diagnosis of lesions of the mediastina it would seem that the second method is operative in the anatomic localization of the lesion, whereas the third is the one which will most surely assist the physician or surgeon in arriving at a correct estimate of the case. It may be taken for granted that the fact of disease in the mediastinum will eventually be verified by radiologic (x-ray) investigation. Such a method of examination, moreover, should prove the site of the lesion to be in either the posterior or anterior mediastinum and at the same time indicate whether it is situated in the upper, middle or lower third of the chest. Pulsation of the mass seen, either true or transmitted, fixation or otherwise to esophagus, trachea, heart or diaphragm may be determined by fluoroscopic examination.

With the information obtained by radiologic investigation, the correct diagnosis is most surely arrived at by a knowledge of the lesions which are to be found in that part of the mediastinum involved.

In addition to a method of subdivision of lesions in the mediastina based upon anatomic differentiation, they may be also divided into two groups depending upon (1) the inflammatory nature of the lesion and (2) its neoplastic character. For purposes of this short contribution diseases of the esophagus will not be considered except for slight reference thereto in connection with inflammatory disease.

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INFLAMMATORY LESIONS

Inflammations, both suppurative due to pyogenic microorganisms and granulomatous due more especially to infection by the tubercle bacillus, are more common than is usually supposed to be the case. In



Fig. 173—X ray pictures of a pyogenic abscess in the posterior mediastinum consequent upon perforation of the esophagus. The gas bubble shown in the lateral picture apparently was due to escape of air from the esophagus since no gas producing microorganisms were discovered. A, Shows lateral projection to the right. B, Shows forward displacement of the trachea. C, Shows a gas bubble in the upper portion of the abscessed cavity.

certain instances trauma is evidently the etiological factor, it may result from perforation of the esophagus by foreign bodies such as bone, false teeth, et cetera (Fig. 173).

'Cold Abscess' of the Chest Wall—One of the commonest inflammatory diseases of the anterior mediastinum is that which is commonly referred to as "cold abscess" of the chest wall. This is characterized by a soft, slightly tender, fluctuating bulge at the edge of the sternum and usually presenting at the second or third interspace. For many years the nature of this lesion was not understood and in consequence results of treatment were unsatisfactory. The commonest diagnosis made was that of chondritis, which was not correct. It would appear that all such anterior wall "cold abscesses" represent, in fact, a suppurative tuberculous lesion having its origin in the lymph nodes which lie alongside the internal mammary vessels.

The most instructive experiments carried out by Hugh Burke of this city seem to have proved conclusively the relationship of both anterior and posterior mediastinal suppuration (due to infection by the tubercle bacillus) to pleural infection.

The correct diagnosis in cases of "cold abscess" of the anterior chest wall is clearly of paramount importance if the disease is to be eradicated. In order that this may be done, adequate exposure of the mediastinum is required. This usually necessitates the removal of two cartilages and perhaps the anterior ends of the corresponding ribs. When this is done the internal mammary vessels are exposed. These should be ligated at the upper and lower borders of the wound and the caseous material which represents the lymph nodes carefully removed. I have made it a practice to carefully biopsy the whole wound and to pack, somewhat firmly, the cavity and to suture the skin flap back into position. If the pack is left in situ for from six to ten days and then removed, prompt healing may with confidence be expected. When this technic is employed, moreover, a soft spot with possible pulmonary hernia is likely to be avoided.

NEOPLASTIC LESIONS

Tumors in the anterior mediastinum are associated with the (1) lymphatic system, (2) thyroid, (3) parathyroid, (4) thymus, and (5) with teratomas. In the posterior mediastinum, apart from the esophagus, the tumors which appear as shadows on radiologic examination are those associated with disease or tumor of the (1) lymphatic system, (2) nervous system, (3) other mesoblastic tumors, and (4) aortic aneurysm.

Lesions Affecting the Lymph Nodes—It will be noted that tumors associated with the lymphatic system may be present in both the anterior and posterior mediastina. Such masses may consist of any one of the diseases which are likely to occur in the lymph nodes. These include acute pyogenic infections, granulomas, especially tuberculosis, and the lymphomas, the most common of which is Hodgkin's disease, although the more malignant types of tumors also may be found and, occasionally, manifestations of the leukemias.

With reference to the leukemias, these rarely present any difficulty in diagnosis since there are well known methods of arriving at a proper solution of the case.

It may be accepted as a general rule that mediastinal masses which prove themselves to be susceptible to x radiation are almost certainly not properly subjected to operative interference. This is true because on the one hand, the malignant lymphoblastomas are incurable and Hodgkin's disease is most properly treated by x radiation alone. It is recommended, therefore, that in the investigation of mediastinal tumors therapeutic roentgen irradiation should be exhibited primarily in order to assist in the diagnosis and, in suitable cases, as the most valuable form of treatment.

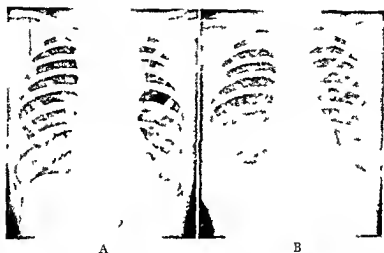


Fig 175 A X ray of chest (Mrs G M) showing Hodgkin's lymphomas B The same chest thirty months after radiation therapy

As a rule, moreover, patients who show mediastinal masses due to diseases of the lymph nodes exhibit enlargement of nodes in other parts of the body, more especially the neck. Specimens are easily removed for histologic examination. This form of biopsy should be carried out since the diagnosis may be most surely established by this means.

There follows an abstracted case report of a case of Hodgkin's disease which although the clinical course has, hitherto, been more favorable than usual, is otherwise typical. It exemplifies, moreover, the application of three important aspects of diagnosis, namely, x ray examination, histologic examination of tissue and the effect of therapeutic radiation.

CASE I HODGKIN'S DISEASE—Mrs G M, aged 33 years, a patient of Dr Nutt, was seen February 1, 1943, at which time she complained of marked shortness of breath and swelling on the left side of the neck. Her complaints dated back five

weeks only. There was no pain. She had suffered moderate loss of weight and complained that she tired easily. A ray examination of the chest showed the presence of what larger
be due to ei

thumb. She was admitted to The Montreal General Hospital Central Division. One of the nodes in the neck was removed for histologic examination and proved to be Hodgkins disease of the Dorothy Reed type. Therapeutic x radiation to the left side of the neck and to the posterior mediastinum was carried out over a period of eighteen months, a total dose of 4600 roentgens being employed.

Although no further radiation has been given, the patient has remained well and was recently operated upon for an ectopic pregnancy. While she was in the hospital at this time an opportunity was given to examine her. At the present time there is no evidence of disease of the lymphatic system (Fig 175, B).

Thyroid Parathyroid Tumors—Tumors in the anterior mediastinum having their origin in the thyroid gland are not uncommon and as a rule present a comparatively simple problem in diagnosis. These tumors, as a rule, are adenomas, are usually cystic and are commonly associated with symptoms referable to distortion of the trachea.

Parathyroid adenomas, associated as they are with changes in the bones, have been shown by Churchill to be found frequently in the anterior mediastinum. He has suggested that, in the event of a diagnosis of parathyroid adenoma having been arrived at by radiologic examination of the bones and by metabolism studies with special reference to calcium, should exploration of the neck fail to reveal the expected tumor, the anterior mediastinum should be explored at a later date. Halisteresis due to hyperparathyroidism is rare, the diagnosis therefore, of parathyroid adenoma is one which should properly be left to the expert.

The following case history with its accompanying illustration illustrates one of the more important common lesions of the mediastinum.

CASE II THYROID IN ANTERIOR MEDIASTINUM—F. J. C. a man 80 years presented himself in 1936 on account of recurring attacks of a choking sensation. Examination showed his general condition to be reasonably satisfactory for his years. Above the sternum could be seen and felt a somewhat movable mass about the size of a golf ball. This lay to the right of the trachea and bobbed up and down into the anterior mediastinum—the diving goner of Lahey.

X ray examination showed compression of the right side of the trachea due to the mass (Fig 176). In consequence of the distressing character of the choking attacks interference was advised and removal of a cystic adenoma of the thyroid with recent hemorrhage into one of the larger cysts was accomplished without difficulty and with complete relief of symptoms. The old gentleman died six years later without return of symptoms referable to the neck or mediastinum.

Hypertrophy and Tumor of the Thymus—The opinion of those who have had most experience, more especially I believe in this connection Blalock, is that myasthenia gravis is in some way associated with hypertrophy or tumor of the thymus gland. It would seem that proven cases of myasthenia gravis should be subjected to exploration of the ante

rior mediastinum. The preoperative diagnosis of this odd and very distressing disease in such cases can scarcely be elaborated upon in this short contribution. With regard to the operative procedure Blalock has urged the importance of adequate exploration in order that all thymus tissue may be discovered and removed.

Carcinoma of the thymus is rarely, if ever, diagnosed while the lesion is operable. As indicated by the last sentence, such tumors are extremely malignant and rapidly spread to the hilar lymph nodes and in a retrograde fashion involve the lung. The possibility of this type of malignant lesion must be borne in mind since the prognosis either



Fig 176—Large diving goiter. X ray illustrates displacement of the trachea to the left.

with or without operative interference must be very guarded to say the least.

Anterior Mediastinal Teratoma—Teratomatous tumors in the anterior mediastinum are rare and it would appear that in the early history of such cases the symptoms are of little importance. In consequence by the time teratomatous tumors, either dermoid cysts or true teratomas, are seen by the surgeon they are usually of relatively enormous size and the symptoms are those due to pressure. The diagnosis of these interesting lesions must be arrived at by an exclusion method. Although as a rule they are benign in the sense that they do not tend

to metastasize nor is infiltration a striking characteristic, they are likely to lead to destruction of the individual by their massiveness if left undisturbed. Their surgical removal, however, is accomplished with considerable hazard. Harrington has been able to exhibit dramatic pictures illustrating the operative procedures required.

Aortic Aneurysm—In our experience, the most common cause of a mass demonstrated by x ray examination in the posterior mediastinum has been aneurysm of the arch of the aorta. A differential diagnosis of this condition may be extremely difficult and I believe that all surgeons who have had any considerable experience in opening the chest with a diagnosis of posterior mediastinal tumor have frequently found aneurysm instead. The Wassermann reaction may be negative and the absence of pulsation in many aneurysms when examined under the fluoroscope makes the differential diagnosis between this disease and a posterior mediastinal tumor of neurogenic origin so difficult that often only by means of thoracotomy can the nature of the lesion be determined.

There follows below a case history of a person in whom operation was carried out, since it did not seem to be possible to arrive at a diagnosis by any other means.

CASE III—W. J. C. a man aged 47 years was admitted to my service at The Montreal General Hospital on account of swelling of the neck and face. This condition had lasted for a period of six weeks. Examination showed a large well nourished well muscled man who was free from complaint except that referable to the neck and head which were enormously swollen and somewhat dusky in appearance. It seemed clear that this condition was due to pressure on the superior vena cava or on the innominate veins although there was no swelling of the arms and no gross enlargement of the subcutaneous veins.

X ray examination of the chest showed enormous masses in the upper third of the thoracic aperture (Fig. 177). Careful examination whatever Prior to the patient's admission to hospital several Wassermann reactions had all been negative. Two Wassermann reactions after his admission to hospital were likewise negative. However the test was repeated following operation and found to be positive.

Although the likelihood that we were dealing with aneurysm was appreciated it was deemed advisable to perform a thoracotomy in order that at least a prognosis might be given to the patient and his family. The right chest was opened through the bed of the sixth rib through a posterolateral incision following institution of artificial pneumothorax. Even after the chest had been opened it was not at first quite clear whether the enormous masses which presented were neoplastic in character or aneurysms since pulsation could not at first be demonstrated. Only after the aorta had been identified at its egress from the pericardium did it become clear that the masses constituted in fact aneurysms of the arch.

As a matter of further interest, it might be pointed out in this case that, although no special effort had been made to displace the masses from the thoracic aperture, the very fact of manipulation in order to prove the nature of the lesion had evidently sufficed to displace them.

to a certain extent at least. We were gratified, therefore, to know that following operation the swelling of the face and neck subsided and the patient returned home on the eleventh postoperative day, comfortable and with an outline to his physician of an adequate course of anti-luetic treatment. He was advised to be cautious as far as strain was concerned but otherwise to carry on with his occupation. A report received six months after discharge from the hospital indicated that he was comfortable and engaging in a reasonable amount of activity.

Neurogenic Tumors—Although odd tumors such as lipoma, myxoma and fibroma, either benign or malignant, are occasionally encountered

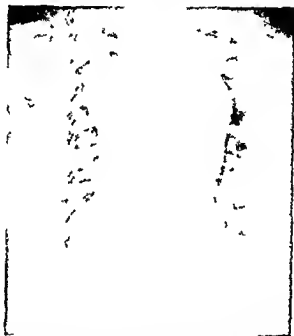


Fig 177 X ray showing aortic aneurysms arising from the ascending and descending branch of the aortic arch. Encroachment of the large masses upon the thoracic aperture is clearly indicated.

in the posterior mediastinum, they are very rare. The presumption is that a true tumor in this location has its origin from the nervous system, either the autonomic or sympathetic. As a rule such tumors are benign or, at most, mildly malignant. This is, however, unfortunately not always the case since there may occur extremely embryonic types of neurogenic neoplasms in the posterior mediastinum.

As a rule the neurogenic tumors encountered in the posterior mediastinum are slow growing and present few symptoms, although it is easy to understand why pressure on the nerves (intercostal) may cause pain and also why, when the tumors are situated in the upper part of

the thorax, even though they do not arise from the sympathetic system, involvement of the ganglia may take place with the development of Horner's syndrome. It should, therefore, be borne in mind that the so-called Pancoast syndrome due to pressure of a neoplasm pushing into the superior aperture of the thorax and producing symptoms of pressure on both the seventh and eighth cervical roots and the sympathetic plexus may take place.

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THE IMPORTANCE OF BRONCHOSCOPY IN PLANNING THE TREATMENT OF PULMONARY LESIONS

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Owing to the specialized nature of bronchoscopic examination and the consequent scarcity of skilled bronchoscopists outside the larger medical centers, there is a danger that this important part of the investigation of certain pulmonary and pleural lesions may be too frequently dispensed with. In the surgery of the genito urinary system the value of endoscopic investigation of the urinary passages has long been recognized and no urological examination is complete without a cystoscopy. Similarly, proctoscopy and sigmoidoscopy are now considered essential in the investigation of disease of the lower bowel. In the same way in order that a complete investigation be made of certain pulmonary and pleural diseases and in particular in order that intervention should not result in serious blundering it is often essential that the lower respiratory passages be thoroughly investigated preoperatively. One need only reflect on the great frequency with which pulmonary disease originates in or is associated with disease of the bronchi to see the force of this statement. The air filled lungs lend themselves so admirably to investigation by x ray and the time honored methods of physical examination that there is a tendency to stop there. In actual fact the seat or a large part of the trouble may be located in the bronchial passages which are by no means so amenable to examination by x ray or stethoscope.

The three great divisions of pleuropulmonary disease that the surgeon is called upon to treat are (1) tuberculosis, (2) nonspecific suppurative disease and (3) neoplasm.

TUBERCULOSIS

Within the past decade increasing importance has been assigned to associated tracheobronchial involvement in tuberculosis of the lungs. Tuberculous bronchitis commences in the submucosa advances to ulceration of the mucosa and finally tends to heal by fibrosis leading frequently to stenosis of the bronchi or trachea. It is now believed that involvement of the smaller bronchi is part of the picture in almost all cases of pulmonary tuberculosis. In 10 to 15 per cent of cases however, the disease tends to progress into the larger air passages leading to certain grave complications. It should be emphasized that these cases are not necessarily those showing the most advanced

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parenchymal involvement. Frequently the bronchial disease seems to take on a course of its own, irrespective of the behavior of the pulmonary lesion, spreading upwards to involve the trachea or bronchi of the opposite side. The most important complications are due to interference with drainage of the infected secretions from the involved pulmonary segments. Atelectasis and later abscess formation may result. Later still bronchiectasis may develop.

It has been shown that patients with tuberculosis of the larger bronchi particularly in the ulcerating and stenosing stages, are not benefited by the milder forms of collapse therapy such as pneumothorax and diaphragmatic paralysis. Furthermore, it has been found that if these ordinarily effective therapeutic measures are adopted in such patients the disease often progresses rapidly thereafter. They respond somewhat better to collapse by thoracoplasty, although why they should, has never been adequately explained. It is possible that pneumothorax and diaphragmatic paralysis impede drainage further by interference with the mechanism of coughing and that thoracoplasty does not operate in this way. In any case, once the presence of bronchial tuberculosis is established, it becomes necessary to observe the behavior of the lesion through the bronchoscope. The only form of treatment that has been widely adopted is repeated cauterization of ulcers and granulation tissue, with 30 per cent silver nitrate. In this way the obstructing granulation tissue is gradually destroyed and the indolent ulcers are stimulated to promote healing. In fibrous stenosis it is doubtful if any form of local treatment is of use and bronchopulmonary resection is indicated. Opinions differ as to the value of silver nitrate treatment but it continues to be practiced by many of the closest students of the disease, and it is probable that a positive statement concerning its efficacy can now be made. At any rate it is the best treatment we know of at present. Furthermore, the most efficient method we possess of providing drainage of the occluded or partially occluded bronchopulmonary segments is by bronchoscopic aspiration. Should the bronchial tuberculosis continue to advance despite the bronchoscopic treatment, it is likely that the only form of treatment that will save the patient's life is resection of the diseased lung and bronchus.

It is clear that information that can be obtained only by bronchoscopy is necessary if the correct form of treatment of certain types of pulmonary tuberculosis is to be followed. More important still, if owing to the lack of this information, an incorrect form of therapy is chosen tragic circumstances may rapidly ensue. Obviously, the ideal is to have every case of pulmonary tuberculosis bronchoscoped. This aim is at present impractical until more skilled bronchoscopists become available. In the meantime, every patient with signs and symptoms suggesting bronchial tuberculosis should have bronchoscopy before any form of active therapy is undertaken. These signs and

symptoms are (1) wheezing, (2) irritating cough, (3) difficulty in raising sputum and (4) dyspnea. In most institutions for the tuberculous, indirect laryngoscopy forms a part of the routine examination after admission. It is important indeed to see the condition of the larynx, but in many cases it is far more important to know the state of health of the deeper and narrower portions of the air passages upon whose patency the whole success of the future conduct of the case may depend.

NONSPECIFIC SUPPURATIVE DISEASE

This includes *bronchiectasis* and *lung abscess* and these conditions often coexist. In both of these diseases bronchoscopy is important for determining the etiology as well as the extent and localization of the lesion.

The etiology of bronchiectasis is still obscure but it is commonly divided into two forms, acquired and congenital, and in the acquired form at least it is often associated with bronchial stenosis and atelectasis. The cause of the bronchial stenosis, whether for example inflammatory stricture or neoplasm, can usually be determined only by bronchoscopy.

It is now quite generally accepted that the only completely satisfactory treatment of bronchiectasis is eradication of the diseased lung by resection. Nevertheless, while in the child and young adult the results of resection are excellent, the risk of operation increases with age, and in the older patient, a medical regimen must often be resorted to. If a medical regimen is decided upon, drainage of the affected segment of lung by posture constitutes an important part of the treatment, but often repeated bronchoscopic aspiration is the only way to obtain efficient emptying of the diseased bronchi.

One of the greatest risks of lung resection in bronchiectasis depends on the presence of copious infected secretions in the tracheobronchial tree. These may either occlude the airway during the operation or flow over into healthy parts of the lung leading to postoperative pneumonia or atelectasis. Preoperative and postoperative bronchoscopy is the only adequate safeguard against such complications. The extent of the bronchiectasis is determined preoperatively by bronchography. This involves instillations of radiopaque oil into all segments of the suspected lung and observation of the filled bronchi by fluoroscopy and x-ray. In many cases thick purulent sputum interferes with bronchial filling and here again preliminary bronchoscopic emptying of the bronchi is necessary to secure a reliable bronchogram.

The etiology of lung abscess is better understood than that of bronchiectasis. Two factors in particular, namely aspiration of infected material from the nose, mouth and throat and septic emboli, are known to be important. In children the aspiration of foreign bodies, notably peanuts, is a frequent cause. Lung abscess, however, is not infrequently seen in bronchial occlusion due to neoplasm. Bronchos-

copy is usually the only means by which bronchial occlusion by foreign body or neoplasm can be ruled out

Transpleural drainage has proved to be the treatment of choice for ordinary lung abscess, but such a measure is obviously at first contraindicated in the presence of bronchial neoplasm or foreign body. The removal of the foreign body via the bronchoscope almost invariably results in cure, whereas bronchial neoplasm usually calls for pulmonary resection. Accurate localization is probably the most important single factor in the successful drainage of lung abscess. Posteroanterior lateral and oblique x-rays as well as tomography are the most essential guides in this respect. However, not every lung abscess is clearly visible on the tomogram or lateral films and in these cases the identification through the bronchoscope of the particular branch bronchus from which the fetid pus originates, may be a valuable localizing detail. In this connection it should be remembered that one can usually see the orifices of at least six branch bronchi on the right side and five branch bronchi on the left side.

Both lung abscess and bronchiectasis may be complicated by empyema. It is clear that transpleural drainage of an empyema will not result in cure if some persisting bronchial disease tends to perpetuate the pulmonary suppuration. Thus, chronic empyema often calls for bronchoscopic investigation.

NEOPLASM

The primary neoplastic diseases affecting the lung are believed to have their origin in the bronchial mucosa and are classified as (1) bronchogenic carcinoma and (2) bronchial adenoma. In approximately 75 per cent of cases of bronchogenic carcinoma the lesion commences in the large bronchi within reach of the bronchoscope. The growth can be inspected, its site and dimensions determined, and biopsy for microscopic examination can be done through the bronchoscope. Much information regarding the extent of invasion of surrounding tissues and involvement of the tracheobronchial lymph nodes can be obtained by noting such signs as fixation of the bronchi and abnormal widening of the carina. The latter signs may also be evident in peripheral bronchogenic carcinoma where the primary growth commencing in a small outlying bronchus or bronchiole is not visible through the bronchoscope, but in which the regional lymph nodes are frequently involved at an early stage.

One can see that bronchoscopic examination is of primary importance in separating the operable from the inoperable. As a life-saving measure, it is of even more importance in guiding the surgeon as to the necessary site of division of the main stem bronchus, to insure complete eradication of the cancer. It is evident that no case of bronchogenic carcinoma should be operated upon without a preliminary bronchoscopy.

Bronchial adenoma is the subject of some controversy as to whether it should be regarded as a purely benign or a potentially malignant neoplasm. Its histology suggests a relation to the so called mixed tumors of the salivary glands which, though commonly regarded as benign, are nevertheless notoriously liable to recur and finally show signs of invasion of the neighboring tissues. In any case, owing to their tendency to obstruct the bronchus, these tumors commonly lead to atelectasis and pulmonary suppuration. They are, moreover, frequently the cause of profuse hemoptysis. On these accounts it is obvious that their removal is a matter of urgency. Those who believe them to be benign are content with removal through the bronchoscope. It is probable that bronchopulmonary resection is, however, the safest form of treatment. Whichever method is adopted, bronchoscopic examination and biopsy are evidently the first step in the attack on the tumor.

Owing to failure to demonstrate a primary tumor elsewhere in the body, it occasionally happens that difficulty arises in differentiating secondary from primary *carcinoma* in the lung. In this connection it should be remembered that bronchogenic carcinoma not infrequently causes metastases throughout one or both lungs probably owing to retrograde lymphatic permeation or hematogenous dissemination. In such a case bronchoscopy is necessary in order to rule out the possibility of a hidden primary growth in the bronchus.

HEMOPTYSIS

Hemoptysis is a development dramatic in its manifestations, usually serious in its implications and quite frequently obscure as to its causation and situation. Owing to the traditional method of treatment, namely, strict immobilization with ice bags on the chest, and opiates in large doses, it is not surprising that the mystery shrouding this condition tends to persist. It is not difficult to see in addition that some of the most serious results of hemoptysis are encouraged and accelerated by the traditional plan of treatment. True, strict bed rest will diminish respiratory movement, but it is very doubtful if this is of more than the least help in diminishing bleeding from the lungs or bronchi. Opiates by dulling the cough reflex may prevent the reopening of a bleeding point, but their chief effect is to hinder evacuation of blood clot already in the bronchi which leads to atelectasis, infection and in the case of tuberculosis widespread dissemination of the disease. The ice bag acts more as a solace to the patient's friends and attendants than as a help to the afflicted one.

Hemoptysis in the majority of cases is a development which calls for action, rather than inaction. It is of primary importance to find out (1) What is causing the bleeding? (2) Where is the site of the bleeding? In tuberculosis of the lungs the cause may be evident but often the site is unknown. In other conditions commonly asso-

ciated with hemoptysis such as pulmonary suppuration, neoplasm and other forms of bronchial ulceration, the cause as well as the site of the bleeding is often obscure. Despite the value of the chest x-ray in the investigation, it can be said that both the cause and the site are often most directly approached by bronchoscopy. If the lesion is within reach of the bronchoscope its nature may be determined. If the bleeding occurs more peripherally, the bronchopulmonary segment involved can be accurately identified by noting through which branch bronchial orifice the blood is issuing.

The obvious objection to early bronchoscopy in hemoptysis is the fact that further bleeding may result from coughing or trauma caused by the intervention. Both cough and trauma, however, can be largely eliminated by adequate preoperative narcosis and skill in manipulation. Moreover, it has never been proved that coughing causes hemoptysis and even if it does, the advantages to be gained from bronchoscopy are sufficiently great to overrule the objection. It is certain that if cough is prevented it is necessary to provide some other form of clearing mechanism for the airways. The most efficient method is aspiration through the bronchoscope. Once the cause and site of the bleeding are determined, active measures can be undertaken to prevent further bleeding. In tuberculosis, collapse therapy in the form of pneumothorax, diaphragmatic paralysis and thoracoplasty is often effective. In other tuberculous cases only bronchopulmonary resection will suffice, and this is also often the case in bleeding due to non-tuberculous disease.

Finally, in all cases of chronic chest disease exhibiting obscure densities in the x-ray, the next logical step in the investigation is bronchoscopy.

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THE BLOOD PICTURE IN PATIENTS WITH PRIMARY CANCER OF THE LUNG

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VITAL statistics, hospital admissions and autopsy records reveal that cancer of the lung is increasing in incidence. Within the past decade there have been a sufficient number of reports of the surgical cure of this disease to warrant stressing the importance of early diagnosis. Not infrequently the physician is confronted by the clinical picture of a middle aged man who has a cough or some upper abdominal discomfort which is annoying but does not interfere with the patient's everyday chores. On examination of the chest and abdomen the physical signs are essentially negative. A roentgenographic examination of the chest may reveal a small localized opacity which appears to be of no immediate importance. The blood count is essentially within normal limits. Because of these minimal changes the physician might dismiss the possibilities of the patient having a primary cancer of the lung.

Most standard works in hematology state that in the majority of cancer cases there is an anemia, an hemoglobinopenia, a lowered erythrocyte count, a reduced color index, a leukocytosis and a polymorphonucleosis. These observations were apparently made in cases of cancer of the gastrointestinal tract and are not directly transferable to cases of cancer of the lower respiratory tract.

Hemoglobin and Red Blood Cells—In 200 cases of proven bronchogenic carcinoma in which 240 hemoglobin (Sahli) determinations were made, it was below 50 per cent in five instances (2.1 per cent), between 66 and 75 per cent in forty one instances (17.1 per cent) and in fourteen cases (5.8 per cent) it was between 96 and 107 per cent. In eight cases it was 100 per cent and above. The lowest hemoglobin encountered was 42 per cent and the highest was 107 per cent. The increased hemoglobin is explainable on the basis of an hemoconcentration, stimulation of the bone marrow, and/or a compensatory polycythemia due to anoxemia. The anemia may be due to ulceration and blood loss either from recurrent hemoptysis or hemorrhage into the pleural cavity, to generalized carcinomatous metastases especially to the bone marrow and/or to nutritional disturbances.

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Morrison for his kindly

The total number of red blood cells per cubic millimeter of peripheral blood in the 200 cases (240 determinations) revealed that in only three instances (1.3 per cent of the determinations) was there less than 2.5 million. In 58 per cent of the determinations the number of cells was above 4 million. According to Morrison the number of red blood cells, in cases of malignancy at all sites, falls below 3 million in 13 per cent of the cases and is between 3 and 5 million in 64 per cent

Hemoglobin	Number of Determinations	Per Cent
Below 50 per cent	5	2.1
51 to 65 per cent	43	18.0
66 to 80 per cent	97	40.7
81 to 95 per cent	81	34.0
96 to 107 per cent	14	5.8

of the cases. He states, "It is obvious therefore that about two thirds of malignant cases show a slight depressed or almost normal count (3 to 5 million per cu mm), one eighth a moderately depressed count (below 3 million per cu mm) and one-fifth normal or increased count (over 5 million per cu mm)." In the present series it was below 3 million in but 5.1 per cent of the cases and in 84.1 per cent of the cases it was between 3 and 5 million. In twenty-seven cases it was above 5 million in seven of which it was above 5.5 million.

Red Blood Cells per Cu Mm	Number of Determinations	Per Cent
Below 2.5 million	3	1.3
2.5 to 3.0 million	9	8.8
3.0 to 4.0 million	89	37.4
4.0 to 5.0 million	112	46.7
Above 5.0 million	27	11.4

Those factors which operate to increase or reduce the hemoglobin will also contribute to the corresponding changes in the number of erythrocytes. In addition, the toxicity may reduce the red blood cells even further that is commensurate with the reduction in hemoglobin. In a series of twenty-four cases of primary cancer of the lung reported by Eisen he found an average hemoglobin of 74 per cent with an erythrocyte count of 4,130,000 per cu mm. In two cases (8 per cent) it was over 5 million, in nine (38 per cent) it was between 4

and 5 million and in the remaining thirteen (54 per cent) it was between 3 and 4 million—none was below 3 million. Eisen attributes the high erythrocytic value to an hemoconcentration.

In sixty-two cases coming to necropsy within one month after the first recorded blood count, the hemoglobin—and to a lesser degree the total number of red blood cells per unit of volume—were only slightly lower than the average for the entire series. The lowest recorded hemoglobin was 42 per cent (with a total of 3 million red blood cells per cu mm) and the highest was 103 per cent (with a total of 5.35 million red blood cells in the same volume).

Hemoglobin	Number of Determinations	Per Cent
Below 50	3	3.9
51 to 65	15	19.8
66 to 80	29	38.2
81 to 95	27	35.6
96 to 103	2	2.6

In the necropsied cases over 87 per cent had a total red blood cell count of from 3 to 5 million per cu mm and only 6.6 per cent were below 3 million.

Red Blood Cells per Cu Mm	Number of Determinations	Per Cent
Below 2.5 million	1	1.3
2.5 to 3.0 million	4	5.3
3.0 to 4.0 million	22	29.0
4.0 to 5.0 million	45	58.5
Over 5.0 million	4	5.3

In this group of cases, then, 23.7 per cent of the determinations revealed hemoglobins of less than 65 per cent, 38.2 per cent were between 66 and 80 per cent and the remaining 38.2 per cent of the studies were above 80 per cent, thus indicating that in relatively few cases of primary cancer of the lung is there more than a moderate anemia even in those subjects who are about to die. Graham, Singer and Ballou noted that secondary anemia occurred frequently in patients with primary cancer of the lung although it was not a constant feature even in the advanced stages of the disease. They observed hemoglobins varying from 51 per cent to 105 per cent and a variation

in the red blood cell from 2.5 to 6.5 million per cubic millimeter. In nine cases Miller and Jones found that there was a moderate anemia as reflected in the hemoglobin and total red blood count. In thirty-three cases of bronchiogenic carcinoma Weigl found that the hemoglobin content and the erythrocyte count were slightly reduced in advanced cases and in only three cases was there an appreciable secondary anemia. The seventeen cases reported by Simpson showed that the red blood cell count did "not appear to be of any importance, it being normal or showing a secondary anemia of moderate degree." In all cases of primary cancer of the lung the erythrocytes showed a variable degree of immaturity as evidenced by reticulation, nucleation and the presence of erythroblasts.

Color Index—In the 200 cases of primary pulmonary cancer in which the hemoglobin and the number of red blood cells per cubic millimeter of peripheral blood were determined, the color index was variable. However, it was not as abnormal as is seen in other forms of malignancy—particularly those of the gastrointestinal tract. The color index

Leukocytes per Cu Mm	Number of Determinations	Per Cent
5 000 to 8 000	30	17.6
8 000 to 10 000	46	19.3
10 000 to 12 000	47	19.7
12 000 to 15 000	61	25.6
Above 15 000	56	23.5

was between 0.9 and 1.1 in 127 (54.2 per cent) of the determinations, above 1.1 in twenty-seven (11.3 per cent) and in eighty-two or 34.4 per cent of the studies it was below 0.9. This determination depending as it does upon an arbitrary standard of 5 million red blood cells per cubic millimeter of peripheral blood and a 100 per cent hemoglobin fails to consider the normal variations with age. However, these determinations do indicate that the hypochromic anemia usually found in other forms of cancer is not common in patients with primary cancer of the lung even before the patient's death.

Leukocytes—In general, it is recognized that about half the patients with malignant neoplasms have a leukocytosis. In the 240 blood counts there were 144 (68.8 per cent) in which the total white blood cells were above normal (leukocytosis), in thirty or 12.6 per cent it was below normal (leukopenia) and in the remaining forty-six (19.3 per cent) it was within normal limits. In the studies in which a leukopenia was encountered, seven had less than 6000 cells per cubic millimeter. The lowest white blood cell count was 5030. Morrison reported fifteen cases of primary cancer of the lung in which ten (66.7 per cent) had

a leukocytosis, three (20 per cent) were within normal limits and two (13.3 per cent) had a leukopenia. He points out that a stimulative effect is produced by the neoplastic process inducing hyperplastic changes in the bone marrow and often resulting in a low grade leukocytosis. The present series contains fifty six instances in which the leukocyte value was above 15,000. The total white blood cell count per cubic millimeter distribution was as follows:

Leukocytes per Cu Mm	Number of Determinations		Total Number of Determinations
	Non autopsied Cases	Autopsied Cases	
15 000 to 18 000	19	3	22
18 000 to 21 000	10	5	15
21 000 to 24 000	4	4	8
24 000 to 27 000	1	0	1
27 000 to 30 000	1	1	2
30 000 to 33 000	0	1	1
33 000 to 36 000	0	2	2
Above 36 000	1	5	6
Total	36	20	56

The thirty six non autopsied cases included only two cases in which there was a leukocytosis above 27,000 whereas in the twenty autopsied cases it was found eight times. In the non-autopsied cases the highest total white blood cell count was 37,200 per cu mm. This was preagonal, the blood being taken shortly before the patient expired. The other cases in this series all survived more than one month after the date of the recorded blood count. In the twenty studies made on autopsied cases the determinations were all made within one month of the patient's demise. In the latter group and in those in which the count rose above 36,000, the totals ranged from 36,200 to 52,000 cells per cubic millimeter. Bergmark and Quensel reported the case of a 31 year old woman with a cancer of the lung. On admission the total white blood cell count was 22,500 per cu mm. Three days later it rose to 40,600 and another two days later (i.e., one day before the patient died) it rose to 66,500. Such premortal fluctuations were also observed in the cases reported herein.

In the fourteen cases reported by Simpson in which the white blood cell count was recorded there was a leukocytosis in four of from 10,000 to 20,000 and in the remaining eight cases it was between 6000 and 10,000. Graham, Singer and Ballou found a leukocytosis above 10,000 at some state of the disease in twenty of their twenty six cases.

In the twenty cases reported by Miller and Jones leukopenia (below 8000) was found in 15 per cent of their cases, a relatively normal count in 10 per cent and a leukocytosis in 75 per cent of the cases. The highest white blood cell count was 112 000 (typographical error?). An increase in the white blood cells may be due to several causes: (1) hemoconcentration, (2) associated and secondary intrapulmonic infection, (3) toxic effects resulting from the absorption of the end products of tissue destruction by the neoplastic and associated inflammatory processes, (4) a stimulation and/or irritation of the bone marrow and (5) recent hemoptyses. On the other hand, a leukopenia may be due to (1) an associated overwhelming infection, (2) widespread metastases to bone and (3) the depressing effects of roentgen rays on bone marrow function, in patients receiving x ray therapy.

Differential Leukocytes—A differential white blood cell determination generally reveals an elevation of the polymorphonuclear neutrophils with a corresponding decrease of the lymphocytes. In 72.5 per cent of the studies the neutrophils were above 70 per cent, a corresponding lymphopenia (below 30 per cent) was observed in 90 per cent of 234 differential counts. Monocytes were found present in 177 out of which number a monocytosis ranging from 6 to 10 per cent was observed in forty one. Eosinophils were found in ninety five blood studies but only on three occasions did they constitute more than 5 per cent of the total number of white blood cells.

Per Cent Cells	Polymorphonuclear Neutrophils	Lymphocytes
1 to 10		26 (11.2 per cent)
11 to 20		110 (47.3 per cent)
21 to 30		74 (31.8 per cent)
31 to 40	1 (0.43 per cent)	20 (8.6 per cent)
41 to 50	3 (1.3 per cent)	1 (0.4 per cent)
51 to 60	7 (3.0 per cent)	3 (1.3 per cent)
61 to 70	54 (23.2 per cent)	
71 to 80	105 (45.1 per cent)	
81 to 90	56 (24.0 per cent)	
91 to 100	8 (3.1 per cent)	

The highest polymorphonucleosis encountered was 95 per cent with a corresponding lymphocytopenia of 2 per cent and 3 monocytes.

Studies on the relation of the duration of the patient's symptoms, site of location of the tumor and cytology of the neoplasm to the specific blood picture show no correlation except that in subjects with more rapidly growing tumors and/or generalized metastases, especially to osseous tissue there is a more marked anemia and a more pronounced leukocytosis.

THE RADIOLOGICAL DIAGNOSIS OF CERTAIN DISEASES OF THE LOWER ESOPHAGUS

J W McKAY, MD, CM *

THAT the radiological examination of the esophagus is indicated in the presence of dysphagia is well recognized. That it is indicated in the search for the cause of other symptoms referred to the thorax is not so well known. Pain of thoracic origin will bring to mind the possibility of heart disease, but it should be remembered that an identical pain may be caused by esophageal disease.

A careful clinical examination should always precede the x ray examination and the pertinent findings of this examination should be available to the radiologist, so that he can conduct and interpret the radiological findings to the best advantage.

TECHNIC OF THE RADIOLOGIC EXAMINATION

Technic is important. The patient should abstain from food or drink for twelve hours preceding the examination. Retained food or fluid is undesirable and interferes with the demonstration of the finer anatomical and physiological details.

A mixture of barium sulfate and water is a satisfactory opaque medium. The apparatus consists of a fluoroscopic table equipped with a spot film device.

A preliminary screening of the thorax is done to exclude disease of the aorta, mediastinum, lung or diaphragm. The patient is then placed prone upon the fluoroscopic table in the Trendelenburg position with the left shoulder elevated toward the fluoroscopic screen. A mouthful of thick paste is administered and instructions are given not to swallow until the examiner is ready to watch the progress of the bolus through the pharynx and esophagus. As the bolus reaches the lower end of the esophagus, instructions are given to take a deep breath, hold it and bear down, as during the act of defecation. This is the *Valsalva test*. As a result of this maneuver, the diaphragm descends and the esophagus is constricted at the level of the diaphragm. Above the constriction there appears a localized pear shaped dilatation of the esophagus. The dilatation is called the phrenic ampulla. In certain individuals, the ampulla will appear (Fig 178) without specific instructions as to the necessity of bearing down. The reason is,

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that those people automatically bear down when told to take a deep breath and hold it.

Dr. Frederic Templeton has described, in detail, the effect of the Valsalva test, upon the esophagus. During the performance of the Valsalva test the primary peristaltic wave which originates with the act of swallowing stops 2 to 3 cm. above the diaphragm. Between the point of arrest of the primary wave and the diaphragm the esophagus expands. As the patient continues to hold the breath, barium regurgi-

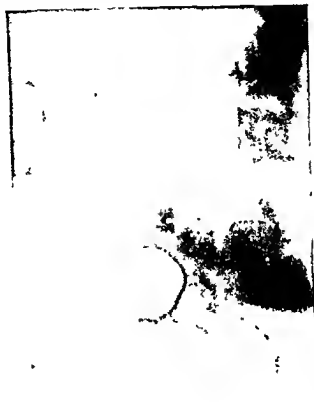


Fig. 178 —The phrenic ampulla during the Valsalva test.

tates upward from the ampulla, and as the regurgitation proceeds, a narrowing, observed at the junction with the ampulla, relaxes and the ampulla collapses. The regurgitated barium partially distends the esophagus above the collapsed portion, revealing the mucosal folds of the esophagus. A second swallow of barium is now given and in the absence of a deep inspiration, the lower end of the esophagus does not expand and the ampulla is not seen. This establishes the fact that the dilatation is the ampulla and not a hiatus hernia.

The primary peristaltic wave originates with the act of swallowing. The wave is a tetanic contraction that may be observed as it progresses

to the diaphragm or to the point above the phrenic ampulla where it is arrested, if the Valsalva experiment is used. The wave produces a stripping effect, leaving sufficient barium behind to coat the mucosal folds of the esophagus.

ANATOMY

The course of the esophagus is of importance because of alterations that may be produced by intrathoracic disease. Pressure effects are produced by adjacent organs that are normally in contact with the esophagus. From above downward these impressions upon the barium-filled esophagus are the aortic arch impression, the left bronchus impression, the left auricle impression and the descending aorta impression.

The impression of the aortic arch is produced by the part of the aorta where the arch begins to descend and is visible in all three of the conventional positions (anterior, right anterior oblique and left anterior oblique). It is best seen with the right shoulder toward the screen which is known as the *right anterior oblique position*. The concavity of the curve is to the left. Alteration of this impression will occur in aortitis, aortic atheroma, enlarged bronchial nodes and abnormalities above the arch of the aorta.

The left bronchus impression is best seen in the right anterior oblique position and is below the aortic impression. It is not always observed and may be confused with the aortic curve. This impression is deformed in enlargement of the glands at the bifurcation of the trachea.

The esophagus is in immediate contact with the pericardium of the left auricle. From the level of the fifth thoracic vertebral body the esophagus leaves the vertebral column and is close to the posterior surface of the pericardium. The impression of the left auricle may be seen in the anterior position as a single curve with its concavity to the left but is best seen in the right anterior oblique position. The displacement backward of the esophagus by an enlarged left auricle is the second most important sign of mitral stenosis, second only to the presystolic murmur.

Above the diaphragm, the esophagus passes to the left, in front of the descending aorta. The impression of the descending aorta is seen in the anterior and left oblique views as a curve, with its concavity to the left.

The esophageal hiatus in the diaphragm is formed by the crura. Harrington states that the muscle of the hiatus is not directly attached to the esophagus and that fixation of the diaphragm to the lower end of the esophagus and to the cardia of the stomach is by way of the diaphragmatico-esophageal membrane. This membrane consists of elastic and fibrous tissue, it originates from the diaphragm and is inserted into the lower 2 or 3 cm of the esophagus and into the upper 1.5 to 2 cm of the stomach. The membrane permits of movement during

swallowing and respiration and it is considered to act as an antagonist to the pull of the longitudinal muscle of the esophagus, preventing them from pulling the cardia through the hiatus. Harrington thinks that atrophy of the diaphragmatico-esophageal membrane, together with relaxation of the muscle of the hiatus, is responsible for the hiatus insufficiency associated with protrusion of the cardia through the esophageal hiatus in older persons.

The anatomy of the lower end of the esophagus is inadequately described in standard textbooks of anatomy. To radiologists, the anatomy is of major importance because of the necessity of explaining the phenomenon of the phrenic ampulla. Templeton has explored the literature rather thoroughly. He quotes from Cunningham, Arnold, Luscka, these anatomists agree that there is a dilatation at the lower end of the esophagus below the diaphragm which they describe as the cardiac antrum. Cunningham and Luscka describe a second dilatation above the diaphragm which is inconstant. Templeton credits Hesse and Strecker (1905) with the first use of the term "phrenic ampulla" for the dilatation of the esophagus above the diaphragm.

Templeton suggests that the position of the diaphragm determines the site of the dilatation. On full inspiration the ampulla is seen above the diaphragm. On expiration a dilatation is not seen. The phrenic ampulla and the cardiac antrum are probably one and the same structure.

Interesting questions arise as to why the ampulla is seen only during full inspiration and why the primary peristaltic wave is arrested at the site of the ampulla.

The wall of the esophagus is composed of striated and smooth muscle, the lower third being largely smooth muscle. There are two muscle layers, longitudinal and circular, an arrangement essential for the propagation of peristalsis. Keith describes an esophageal sphincter at, or above, the level of the esophageal hiatus of the diaphragm.

The mucosa, submucosa and muscularis mucosae form longitudinal folds and are responsible for the mucosal pattern of the barium-coated esophagus. The mucous membrane is lined with stratified squamous epithelium and at the lower end is sharply demarcated from the columnar epithelium of the stomach.

There is an anastomosis between the portal and systemic venous systems at the lower end of the esophagus. The branches of the coronary or left gastric vein form an anastomosis with the veins of the esophagus which drain into the azygos vein, then into the superior vena cava. Short gastric veins pass from the upper pole of the spleen to the greater curvature of the stomach to reach the esophageal veins. These anastomoses explain the formation of varices.

The behavior of the esophagus during the act of swallowing depends upon the consistency of the bolus, the position of the patient and individual peculiarity.

PHYSIOLOGY

In the upright position gravity is the important factor. In certain individuals a watery solution may be simply poured into the stomach without any appreciable act of deglutition. If the drink is taken in mouthfuls the fluid is arrested at the cardiac sphincter until the primary peristaltic wave arrives and propels it forward as the sphincter relaxes. If the bolus is dry or the patient is in the prone position the mechanism of the swallowing of solids is brought into play and the

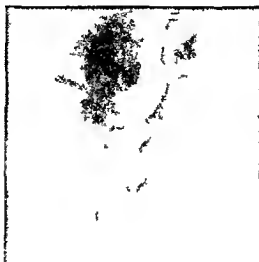


Fig 179 Tertiary peristaltic waves

peristaltic wave is the force that propels the bolus downward. This is the reason why the radiologist prefers the Trendelenburg position for the examination of the esophagus. In this position the passage of the barium is lower and the peristaltic wave may be observed. In addition to the primary peristaltic wave secondary and tertiary peristaltic waves are occasionally observed. Secondary waves may be seen in the presence of obstruction. Tertiary waves produce a peculiar beaded appearance (Fig 179). They should not be mistaken for diverticula or varices.

ESOPHAGEAL HIATUS HERNIA

Although esophageal hiatus hernia is not, strictly speaking, a disease of the esophagus, the close resemblance of the phrenic ampulla to diaphragmatic hernia necessitates a brief discussion of this abnormality.

There are many classifications of hernia based upon cause, site of herniation and contents. In this discussion, we will refer only to esophageal hiatus hernia in which the stomach herniates into the posterior mediastinum. This is the commonest type of diaphragmatic hernia.



Fig. 180—Esophageal hiatus hernia. The entrance of the esophagus into the stomach is obscured.

Harrington describes two types. In the first type the esophagus is of normal length and the lower end is not elevated above the diaphragm, but a portion of the stomach has herniated into the mediastinum beside the esophagus. The hernias are usually small and rarely involve more than one-half of the cardiac end of the stomach. One-third of the esophageal hernias which he has operated upon are of this type. In the second type (Fig. 180) the esophagus is of normal length but the lower end is elevated above the diaphragm and enters the herniated stomach above the diaphragm. This type is larger than the first

type and may even contain the entire stomach with a portion of omentum and occasionally a part of the colon. Harrington believes that the difference in these two types is a matter of degree rather than origin.

These two types are relatively easy to identify because of their large size and the presence of gastric rugae above the diaphragm. The esophagus enters the herniated cardia from the medial side (Fig. 181).



Fig. 181—Esophagus entering herniated stomach from medial side

thus distinguishing this hernia from the short esophagus due to a thoracic stomach. The position of the esophagus is best demonstrated with the patient in the supine position with the left shoulder rotated toward the fluoroscope screen. Marked kinking of the esophagus is not seen. Templeton suggests that the longitudinal muscle contracts and so straightens the esophagus.

We have had no experience in the examination of the congenitally short esophagus. Harrington considers it to be a rare condition. In eleven cases in which the diagnosis was made there were only four in which the esophagus could not be brought below the diaphragm.

at operation. It is probable that the diagnosis of thoracic stomach is incorrectly made because of a failure to rotate the patient in a position to demonstrate the relationship of the esophagus to the herniated stomach.

Hiatus insufficiency (Fig. 182) is another type of hernia described by Harrington which he thinks is due to atrophy of phreno-esophageal membrane and incompetence of the muscle of the esophageal hiatus. It is difficult to differentiate this type from the phrenic ampulla. As previously described, the ampulla is seen during full inspiration espe-



Fig. 182—Hiatus insufficiency

cially if accompanied by a bearing-down effort. This maneuver also assists in demonstrating or perhaps producing the protrusion of the cardiac end of the stomach in hiatus insufficiency. The difference in the appearance of the mucosal pattern of the esophagus and of the cardiac end of the stomach is of value. Harrington states that esophagoscopy may be necessary in differentiating the two structures. If error is made in the interpretation, it is usually in the direction of mistaking the normal ampulla for a hiatus hernia.

CARDIOSPASM

The theories of the etiology of cardiospasm have been adequately discussed by many writers. The x ray picture in the long-standing cases of cardiospasm is characteristic. The esophagus dilates to a marked degree and eventually will become elongated and tortuous. As it increases in size it produces widening of the mediastinal shadow to the right. This increase in width may be seen in a film of the chest even without the administration of barium. The lower end of the dilated esophagus is usually smooth, narrow and conical in shape. The smooth appearance may be altered by complicating esophagitis and ulceration above the obstruction.

The differential diagnosis will be between benign stricture, carcinoma and cardiospasm. Esophagoscopy will be necessary in order to make an accurate differentiation.

The following case observed at The Montreal General Hospital and The Montreal Neurological Institute is of interest because of the association of *cardiospasm* and *angina pectoris*.

G. H., a man aged 46 years, was admitted three times in the period from 1916 to 1929 when the diagnosis of duodenal ulcer was made. This diagnosis was not confirmed at operation when a 'chronic appendix' was removed. The symptoms persisted. A ventral hernia was repaired. In April 1932 the patient complained of vomiting of increasing frequency. Dysphagia developed. Esophagoscopy was done and marked spasm of the cardiac end of the esophagus was seen. Dilatation was done with difficulty. In October 1932 the esophagus was dilated once a week with relief of the dysphagia. During this month the patient was seized with pain in the left shoulder and arm extending to the fingers of the left hand. On October 5 during dilatation the shoulder and arm pain became so severe that he was admitted to the hospital. The diagnosis of *angina pectoris* was made by the late Dr. Henri Lafleur. The electrocardiogram was normal. The blood pressure was 120 systolic and 112 diastolic. Amyl nitrite failed to give relief. The patient continued to complain of dysphagia. Dr. William Cone injected the first, second, third and fourth left sympathetic ganglia with 1:1500 nupercaine. The patient was greatly improved. Slight pain in the left forearm persisted. A ray examination of the esophagus at this time showed no evidence of cardiospasm. Dr. Cone operated upon the patient on December 7, 1932, performing a laminectomy with rhizotomy of the first six left thoracic roots and of the first right thoracic root. After operation the patient was cured of the cardiospasm and of the *angina pectoris*.

Dr. Cone believes that the cardiospasm and the *angina pectoris* were of the same etiology and were due to sympathetic hyperactivity.

Dr. Tinsley R. Harrison points out that any pain that originates in the substernal or precordial region and radiates to the left arm is not necessarily due to heart disease. His report deals with eleven patients. Seven complained of mild substernal or precordial pain with little radiation, the sensation variously described as burning, fullness, tightness or squeezing. The duration was from minutes to hours. In four of seven patients the discomfort was precipitated by swallowing. The x-ray examination of the esophagus was negative in all of the patients.

None of them were examined while the discomfort was present. Fluoroscopic study of the esophagus should be done while the pain is present. In cases without evidence of heart disease and with precordial or substernal pain a fluoroscopic examination should be done of the esophagus in search for esophagospasm.

ESOPHAGITIS

If one consults the records of the pathological department one is forced to come to the conclusion that esophagitis is the commonest disease of the esophagus. X ray observations upon a large series of patients have not been reported. The published cases are described as showing spastic contractions, stenosis and distortion of the mucosal folds.



Fig. 183—Esophagitis

R. I. M., a physician aged 40 years, was observed at The Montreal General Hospital in 1932. He complained of substernal pain at the level of the xyphoid process of several months' duration. An x-ray examination revealed dilatation of the esophagus and a filling defect involving the lower third of the esophagus (Fig. 183). The filling defect was indistinguishable from that produced by carcinoma. The changes were present on more than one occasion but showed some variation in pattern. The variations were probably dependent upon spasm. No crater was demonstrated. Carcinoma was suggested. The patient was examined by Dr.

Chevalier Jackson Endoscopic findings were chronic esophagitis, erosion of the mucosa in the middle third of the esophagus, diffuse dilatation of the lower third. There was a chronic gastritis in the portion of mucosa immediately surrounding the esophageal orifice. The esophageal inflammation had the appearance of a static esophagitis. Dr. Jackson expressed the opinion that the stasis was probably intermittent and due to the failure of the diaphragmatic pinch cock to open promptly. The patient recovered completely. In 1942, an x-ray examination showed a normal esophagus.

TUMORS OF THE ESOPHAGUS

The diagnosis of cancer of the esophagus is usually made late in the disease. All patients complaining of substernal pain, discomfort or dysphagia should have at least a careful radiological examination of the esophagus.

The x-ray examination should begin with a thin watery solution of barium. The thin mixture will pass through a narrowed portion and visualize the extent of the lesion. A thick paste may become obstructed and fail to fill all of the diseased area. The distal extremity of the lesion will be identified by normal mucosal folds. The mucosal folds at the site of the lesion will be obliterated. Proximal to the cancer the mucosal folds may not be entirely normal due to an associated esophagitis. If no evidence of narrowing, spasm or defect is seen with the use of the thin watery mixture a thicker paste should be used. This will reveal lesser degrees of narrowing.

Three gross anatomical types of esophageal cancer are recognized: (1) The stenosing, infiltrating or scirrhus type. This form produces a circular stenosis. (2) The medullary type which ulcerates early. This type will produce an irregular filling defect in the barium-filled esophagus. (3) Polypoid form. It is rarely recognized radiologically.

The cancer is an epidermoid carcinoma. Adenocarcinoma is rare except in the lower end of the esophagus where it is found as an upward extension of carcinoma of the cardiac end of the stomach. With this in mind, x-ray investigation of the cardiac end of the stomach is imperative in the presence of x-ray evidence of carcinoma of the lower esophagus.

Nonepithelial tumors of the esophagus are rare. They have been aptly described by Dr. Richard Schatzke as intramural extramucosal tumors. We have observed two cases that satisfied the criteria for the diagnosis of these tumors. One of the patients refused treatment and so the diagnosis remains in doubt.

N. B., a woman aged 19 years, complained of indigestion of six years' duration accompanied by a burning sensation deep in the chest. For five years she had experienced pain in the chest on swallowing food, and a heavy feeling in the chest relieved by belching and more recently by vomiting. Vomiting without nausea had been present for five months. A spasmodic dry cough was present and she expectorated phlegm containing soft whitish material. She was unable to swallow solid foods. Tarry stools were observed on two occasions.

X ray Examination—There was dilatation of the esophagus. A sharply demarcated tumor mass was seen in the posterior mediastinum projecting to the right of the midline (Fig 184). The esophagus was displaced to the right by the mass which appeared to be intimately associated with the esophagus. The upper and lower limits of the pressure defect were sharply demarcated from the uninvolved esophagus above and below the mass. The wall of the esophagus opposite of the tumor appeared to be normal. The mucosa was distorted but not destroyed.

Esophagoscopy—The esophagoscope was passed without difficulty. The esophagus was dilated. The mucous membrane was injected. At 38 cm there was a sacculaton to the right. There seemed to be pressure from the anterior surface into the sacculaton. The cardia was not seen. Ulceration or evidence of disease of the mucosa was not reported.



Fig 184—Leiomyoma of the esophagus

Operation—Exploratory thoracotomy was performed by Dr Fraser Gurd. A tumor the size of a grapefruit was found presenting in the lower half of the chest. The esophagus was pushed to the right and was dilated. The tumor arose from the wall of the esophagus, and could be separated from the mucosa and submucosa of the esophagus except at the distal extremity. The patient died of postoperative complications.

Special stains revealed in the cells many longitudinal striations but no cross striations. No evidence of malignancy was present.

Diagnosis: Leiomyoma of the esophagus.

The radiological features were consistent with the diagnosis of extramucosal, intramural tumor. There was a circumscribed lobulated mass involving the posterior mediastinum encroaching upon the lumen of the esophagus. The mass was sharply demarcated at its upper and lower extremities by a well defined angle. There was distortion but no destruction of the mucosa.

VARICES

The demonstration of varices as a source of bleeding in the lower esophagus is of great value to the clinician.

Abnormally distended veins will project into the lumen of the esophagus as rounded elevations and as tortuous, elongated defects in the barium coated interior of the esophagus. Varices may be present and not be demonstrable by x ray examination.

Templeton recommends the use of the Valsalva test in demonstrating varices. As the phrenic ampulla appears and the barium regurgitates upward into the esophagus varices may be visualized. He points out that this regurgitation will occur as the esophagus relaxes above the ampulla. The relaxation also permits of filling of the varices. The test should be repeated if varices are not shown at once. This is a useful maneuver.

Diverticulum of the lower end of the esophagus is rare. It is to be distinguished from the phrenic ampulla and esophageal hiatus hernia.

CONCLUSION

Familiarity with the normal physiology and anatomy of the esophagus will prevent errors in radiological diagnosis. The commonest error is in mistaking the phrenic ampulla for an esophageal hiatus hernia. Disease of the esophagus should be considered as a source of thoracic pain. The esophagus should be examined radiologically during the attack of pain.

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THE DIAGNOSIS OF TUMORS OF THE BREAST

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To be in any way inclusive, a consideration of tumors of the breast must deal with chronic cystic mastitis—that condition difficult to name and classify, difficult to diagnose, and difficult to treat.

Art in medicine is the exercise of judgment in the interpretation of symptoms and signs of disease, in order that treatment may be instituted which will reproduce a picture of health. Science in medicine is the extension of observation by exact means of examination. The more complete knowledge thus obtained permits of the exercise of more mature judgment. In no realm of surgery is this more true than in the diagnosis and treatment of tumors of the breast.

Acknowledging that the female breast is of importance from the point of view of both function and appearance, appreciating that the lesion most to be feared and always to be suspected is carcinoma, and realizing that the beginnings of carcinoma must of necessity escape detection by the fingers or the unassisted eye, the surgeon is faced with considerable difficulty in exercising the judgment which will be to the best interest of the patient. To remove a breast, to inflict ugliness and asymmetry, and then to find naught but a harmless lesion, leads to chagrin. To leave an apparently innocent lesion, which later reveals its true nature by causing death, leads to remorse. With accumulating individual experience and intensive study of pathological lesions of the breast, the clinician is ever finding it more difficult to arrive at a definite diagnosis—and peace of mind.

EXAMINATION OF THE BREAST

History—When a patient with a lesion of the breast presents herself for examination, a complete and detailed history should be taken. This is important both for the study of the case and for statistical records. Information should be obtained about time of onset, rate of progress, subjective symptoms, menstruation, menopause, endocrine disorders, pregnancies and lactations, previous operations on breast and pelvic organs, occurrence of trauma, and incidence of cancer among other members of the family.

Inspection—The patient is placed in the sitting position, in a good light, with the clothes off to the waist. The size of the breasts is noted.

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This will vary from the small, flat pseudomascu-line type to the large, obese, pendulous type. One looks for a difference in size or general contour, a change in the direction, the horizontal position, or the relative prominence of the nipples, and an alteration in the appearance of the skin over the breast. The arms should then be elevated and again any change noted in the contours of the breasts. The importance of examination in the sitting position cannot be overemphasized, because a small, deep-seated cancer in a large breast may sometimes be recognized on inspection when it cannot be felt on palpation.

Palpation—The patient is next placed in the recumbent position and palpation is carried out. Flat hand palpation, rolling the breast on the chest wall, will reveal hard tumors such as cancer, fibroadenoma and large cysts, while the tissue changes of chronic cystic mastitis will not be recognized. Further palpation of every part of both breasts between the finger and thumb will reveal the small nodules and variations in consistence of breast tissue so characteristic of chronic cystic mastitis. The nipple should be carefully examined for warts or fissures. If there has been a history of discharge from the nipple it may be possible by gentle stroking to locate the exact segment from which the discharge has come.

At this stage the examiner should chart the information so far obtained using a diagram which divides the breast into five zones—a central zone, two inner zones, and two outer zones. If a lump is present, it should be measured in centimeters and its consistence and mobility recorded.

Finally, the axilla and the infra- and supraclavicular fossae are palpated for enlarged lymph nodes. The condition of the lymph nodes is important as an indication of the prognosis, but should play little or no part in determining the nature of the primary lesion. Under no circumstances should the absence of enlarged lymph nodes be regarded as evidence that a mass in the breast is benign.

No examination is complete without a general examination of the patient, including especially palpation of the liver, x-ray of the chest (particularly when a cough or hoarseness has recently developed), and x-ray of the lumbar spine and pelvis if there is pain in the neck or pain of a sciatic character.

Transillumination—In experienced hands transillumination is of value in differentiating cysts from solid tumors. It is not applicable to flat, nonpendulous or sessile breasts or to lesions in the upper half of the breast. The patient is placed in a dark room and a cold electric lamp with rheostat control is used. Thus light of varying degrees of intensity can be used. The various breast tissues and lesions show different degrees of translucidity. This method of examination is only an aid to diagnosis, and great caution must be exercised in evaluating its findings.

Needling—When the diagnosis rests between a solitary cyst and car-

cinoma, needling or aspiration biopsy will assist in solving the problem. Under local anesthesia a 22-gauge needle can be introduced and the contents aspirated. It is safer to centrifuge the fluid and examine it for tumor cells. A benign cyst will reveal straw-colored or cloudy fluid. Blood-stained fluid is indicative of duct papilloma, intracystic papilloma, or carcinoma.

X-ray Examination—In our experience x-rays (with special soft tissue technic) have been of doubtful value. The breast is a very accessible organ, so that following a detailed examination a decision can be reached as to whether or not aspiration or surgical biopsy is indicated.

Surgical Biopsy—Biopsy is required only when the signs do not definitely indicate a malignant lesion. When biopsy is indicated, the inframammary approach is preferable. If the breast is turned up, the lesion can be reached in no matter what quadrant it is situated. By this method no unsightly scar or asymmetry is produced. Should a radical operation be necessary following examination of the tumor by the frozen section method, it is not difficult to include the inframammary incision in the radical one. Avoid double operations. The actual sectioning of the tumor is preferably done with the electric knife, a cutting coagulation current being used.

CHRONIC CYSTIC MASTITIS

Since Sir Benjamin Brodie's paper on benign cystic disease of the breast was published in 1846, there have been innumerable contributions to the subject. This has led to a state of confusion and disagreement among surgeons and pathologists alike as to views and classification. In spite of attempts to correlate clinical and pathological knowledge, a sound clinical classification does not exist. The reason for this is that the various pathological groups may all be present in the same breast. There is no doubt, however, as intensive study over many years has shown, that some aspects of this disease are definitely precancerous. There has been progress, and we may expect that with time the relationship of chronic cystic mastitis to cancer will be more and more clarified. Many surgeons today consider this disease as precancerous in all its forms and perform wholesale mastectomies—their contribution to the cancer-control problem. Fortunately, however, the majority do not subscribe to this mass mutilation, believing from painstaking investigation, assisted by the work of competent pathologists, that the disease is precancerous in only some of its forms.

Recent studies indicate that the pathological changes observed in chronic cystic mastitis are due to abnormalities in the secretion of ovarian hormones. Two ovarian hormones, the follicular and the corpus luteum, influenced by the anterior pituitary, control the connective tissue and the duct and acinar tissues, respectively.

Chronic cystic mastitis occurs most commonly between the ages of 25 and 50 years, being more frequent in women who have not

borne children. The clinical features of this disease are painful breasts, nodular or lumpy breasts, and a discharge from the nipple. The disease is very often bilateral.

Three clinical types of mammary dysplasia will be discussed, but as mentioned before, all of these pathological changes may be found in the same breast.

Type I (Variously called *Alazoplasia*, *Mastodynia*, *Adenofibrosis*, *Painful Breasts*, etc.)—This condition is characterized by pain in one or both breasts or pain localized to a segment of the breast. The average age period is 35 years and the disease is more common in childless women. The breasts are very often poorly developed. Examination may reveal a tender area of induration confined to a segment of the breast. This tenderness is more pronounced during the premenstruum. Spontaneous disappearance often takes place. On palpation the breast tissue is granular to the feel. Diffuse nodularity is not a feature. Diagnosis is based on pain worse in the premenstruum, often referred to the chest and arms, local tender indurated areas and the absence of nodularity.

Type II (Called *Schimmelbusch's Disease*, *Benign Parenchymatous Hyperplasia*, *Cystiferous Desquamative Epithelial Hyperplasia*, *Adenosis*, *Adenocystic Disease*, etc.)—The chief clinical feature of this type is the presence of nodules varying in size from a few millimeters to a centimeter or so. The pathological features are cyst formation and epithelial hyperplasia. As in the first type the disease is more common in women who have not borne children. The average age is 40 years. One might say that this type represents an advanced stage of Type I.

On examination the breast is firm and often disk shaped and multiple nodules are palpable throughout. Very often a conglomeration of nodules forms a definite mass in one segment of the breast. There may be a serous or a serosanguineous discharge from the nipple. In this type the presence of a definite mass and a knowledge of the pathological features often make biopsy imperative for the ruling out of malignant or precancerous changes.

Type III (Known as *Cystic Disease*, *Polycystic Disease*, *Solitary Blood-filled Cyst of Bloodgood*, etc.)—This type predominates at or after the menopause. It is just as common in parous women as in childless women. The average age is 45 years. The characteristic clinical feature is the presence of large solitary or multiple cysts. These are globular elastic swellings, freely movable in the breast tissue. Fluctuation may be elicited. Multiple smaller cysts may form a triangular area of nodularity, with the base towards the periphery of the breast. A serous or brownish discharge from the nipple may be noted from time to time.

This type is essentially an involutionary process and microscopically

there is diminution in the number of acini and atrophy of the lining epithelium in the large cysts

Aspiration biopsy is used more commonly in this type, in differentiating single cysts from carcinoma

Precancerous Lesions in Chronic Cystic Mastitis—As previously stated, this is one of the most controversial subjects of the present time. In the Montreal General Hospital approximately 20 per cent of those cancers of the breast examined by whole section reveal cystic and papillomatous changes in areas not involved in the malignant process.

The most significant histological feature in areas composed of multiple small cysts is the presence of hyperplasia of the lining of the ducts and acini, which become filled with viable cells, which retain their normal staining properties. Although such features as invasion of the wall of the duct or acinus are not evident, it is agreed by the majority of pathologists that such a picture is precancerous.

This process must always be in the surgeon's mind when examining the breast in chronic cystic mastitis.

SANGUINEOUS DISCHARGE FROM THE NIPPLE

Bleeding must be distinguished from other discharges from the nipple. A brownish discharge which when chemically tested is not old blood and a greenish discharge are found in chronic cystic mastitis. On the other hand, a serous or a sanguineous discharge is significant of duct papilloma, carcinoma and chronic cystic mastitis. Approximately 50 per cent of cases of bleeding from the nipple are malignant. The presence of a single mass in close proximity to the nipple is most significant of carcinoma. However, a mass may not be palpable, and therefore the possibility of duct papilloma must be considered. Careful palpation in the region of the nipple will often reveal an area of thickening in line with the duct. Where no mass is palpable, stroking the breast in its various segments will often assist in demonstrating the source of the bleeding. The breast may be of the nodular type, in which case the difficulty of palpation will be increased.

Bleeding from the nipple must always be regarded as serious, and demands biopsy before a malignant tumor can be ruled out.

BENIGN TUMORS OF THE BREAST

Fibroadenoma—This is the commonest benign tumor of the breast. The incidence is highest in patients between 20 and 25 years of age. It is occasionally found in women after the menopause. Clinical examination reveals a very firm mass with smooth or lobular contours. Because it is encapsulated, fibroadenoma is the most mobile of all the breast tumors. Diagnosis in younger individuals offers little difficulty. In the older age groups, solitary cysts and carcinoma must be ruled out. A fibroadenoma, if not removed, will increase in size and is liable to undergo malignant degeneration.

CANCER OF THE BREAST

Cancer of the breast is second only to cancer of the uterus among malignant tumors in the female. Approximately 75 per cent of mammary cancers occur in women over 40 years of age, and 65 per cent of cases show metastases to the lymph nodes at operation.

There are, unfortunately, no early subjective symptoms in cancer of the breast. In 90 per cent of cases the patient becomes aware of the lump in the breast by its accidental discovery. Only 10 per cent complain of pain as an early symptom. This is never severe, but more in the nature of a discomfort. The pain of chronic cystic mastitis is always worse during the premenstrual period. In cancer, unlike chronic cystic mastitis, there is no exacerbation. Pain is more often a symptom of larger growths.

Only 30 per cent of patients seek advice in from one to three months after the discovery of a lump in the breast.

Such classical features as a firm, single lump, showing fixation, retraction or depression of the nipple, involvement of the skin, and palpable axillary nodes, denote an advanced lesion in which the possibility of cure is remote.

Cancer may develop in any part of the breast, though the upper outer quadrant is the most common site. With very few exceptions it is a solitary lump, which grows diffusely from its point of origin. It infiltrates and therefore becomes fixed, with the result that there is dimpling of the skin, or, if one or more of the larger ducts are involved, there is a change in the direction or a depression of the nipple.

A serous or a seropurulent discharge from the nipple may occur in carcinoma, but this is not an early symptom as a rule.

The first sign of cancer may be the presence of axillary metastases or a spontaneous fracture from more diffuse metastases. The primary tumor may be small, and in large obese breasts, even on careful palpation, it may not be detected.

The *scirrhous* cancer is the most common pathological type. Owing to the greater proportion of stroma to epithelium, it is hard, and when incised it cuts with a gritty sensation. The cut surface is grayish in color with yellowish areas of necrotic cell masses scattered throughout.

The less common variety is the *medullary* cancer, a soft, very cellular growth. This type is rapidly growing and the first sign is often the presence of metastases. The acute carcinoma is an example of the medullary variety. It generally develops during lactation. The growth is so rapid and the enlargement of the breast so pronounced that it is often mistaken for an acute inflammatory condition.

Other varieties of breast cancer are *adenocarcinoma* and *intraduct or comedo* cancer, both of which are of relatively low malignancy.

The *mode of spread* in cancer of the breast is by way of the lymphatic vessels. The axillary nodes are usually involved first, though a

lesion in the medial part of the breast may cause early involvement of the mediastinal nodes. The liver and abdomen are invaded by an extension along the round ligaments. Cancer cells may spread also by way of the blood stream. These cells reach the venous system either by way of the lymphatics or by direct extension into a vein. The lungs and bones are the sites in which blood borne emboli commonly lodge. As stated previously, dissemination may occur at any stage of the disease, and therefore the importance of detailed general examination and roentgenological study cannot be overemphasized. The presence of distinct metastases precludes a radical operation.

PAGET'S DISEASE OF THE NIPPLE

The earliest manifestation is a tiny pin point of superficial ulceration of the nipple. This will increase to a chronic ulceration of the nipple and the surrounding areola. In early cases a fine cord may, on careful examination, be felt proceeding into the substance of the breast, and, if this be situated towards one edge of the nipple, the latter is retracted and tilted toward the same side.

Manipulation may cause blood to exude from the orifice of the involved duct, in addition to the serosanguinous ooze from the ulcerated surface.

There is still much difference of opinion as to the exact nature of this lesion. The consensus is that the primary lesion is a carcinoma usually intraductal, which growing along the duct, approaches the surface and infiltrates the deeper layers of the skin. The replacement of the normal skin covering leads to superficial ulceration. The cancer does not necessarily reach the skin at the site of the nipple only. It may, by lymphatic extension reach the skin in any part of the breast and give rise to a Paget's eczema in that area.

In advanced cases the palpable mass deep to the ulcerated area offers little difficulty in diagnosis.

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ANGIOGRAPHY—AN EVALUATION OF ITS USEFULNESS

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PERHAPS we owe most to R. dos Santos¹ whose ingenious and prolific effort has done much to stimulate interest in the technic of making the vascular system visible by x-ray. Space will not permit an attempt to document or evaluate the many notable contributions to this important field but an attempt will be made to discuss some of the outstanding benefits of angiography.

CLINICAL BENEFITS OF ANGIOGRAPHY

Because of their relatively low toxicity and rapid elimination the iodides are favored as contrast media for the x-ray visualization of the vascular system. Of this group diodrast is a popular compound in America.

Cerebral Angiography—It is indeed a compliment to the many contributors to angiography to state that in the short number of years since its beginning it is now possible to obtain excellent pictures of any portion of the human vascular system. Techniques have been evolved making the safety of angiography in any region entirely commensurate with its diagnostic importance in given instances. This implies that cerebral angiography should not be employed on the slightest provocation but it does mean that when there is a question of serious doubt in diagnosis the cerebral vessels can be visualized safely to rule out, for example, the presence of an arterial aneurysm. We have employed angiography of the vessels of the head to localize more accurately the site of a traumatic arteriovenous fistula. In cases of congenital arteriovenous aneurysm of the cerebral vessels important information may regularly be gained from angiography.

Aortography.—Serial Contrast Method—The right common carotid artery has been used for retrograde visualization of the arch of the aorta employing a long, flexible needle with a tapered blunt stylet. Visualization in sequence by x-ray of the superior vena cava, heart chambers, pulmonary vessels, aorta and branches following the rapid introduction of 70 per cent diodrast in an arm vein represents a truly great achievement in angiography. The technic for carrying out this method was masterfully achieved and meticulously presented by the originators, Robb and Steinberg.² These investigators reported a sufficiently substantial experience to leave no doubt as to the safety,

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practicality and worth of the procedure, all of which has been adequately corroborated by others

Applications—In cardiovascular disease the above method of contrast roentgenography has given a degree of precision in diagnosis previously unattainable. It may aid in the diagnosis and treatment of the various types of mediastinal disease. The most striking results are obtained, however, in disorders such as aneurysm of the pulmonary artery, aortic disease, and pericardial and congenital abnormalities in which recognition is difficult or impossible with conventional methods of study. Whereas the technic of carrying out serial contrast roentgenography following opacification is exacting, proficiency in the



Fig. 185—An x ray of the heart made in the left anterior oblique position three seconds after the intravenous injection of 35 cc. of 70 per cent diodrast in the right median cubital vein

procedure can be readily acquired through training and practice, and successful performance should be within the capability of every medical center

Figure 185 is an x ray taken three seconds after the rapid introduction of 35 cc. of 70 per cent diodrast in a vein of the right arm. Opacification of the aortic arch is apparent in profile. The fact that the diodrast has made the aorta and its upper branches visible three seconds after injection is proof simple of the existence of a *perforate intraventricular septum*. The right auricle and right and left ventricles are seen to be filled with diodrast—a further proof of the presence of a *perforate intraventricular septum*. The intraventricular septum (see

arrows) separates the right ventricle from the smaller left ventricle below but is incomplete above leaving a large defect. The dextroposition of the aorta is to be noted. This is a case of tetralogy of Fallot in a twenty-one-year-old boy. Failure in visualization of the pulmonary artery suggests the presence of pulmonary stenosis. Failure in visualization of the pulmonary artery likewise suggests the absence of a patent ductus.

Satisfactory visualization of the arch of the aorta for the diagnosis of *aneurysm* or *patent ductus* has been attained by the retrograde injection of a contrast medium through the right common carotid artery or the right brachial artery.



Fig. 186. An x-ray of the heart taken in slight left anterior oblique position showing opacification of the aorta following the rapid introduction of 35 cc. of 70 per cent diodrast through a needle in the ascending arch.

Perhaps the best aortograms have been made by dos Santos and his co-workers. These investigators have perfected a pressure apparatus and special technic for the rapid injection of the radiopaque medium directly into the aorta with a needle.

I have found aortograms extremely useful in checking the degree of clotting within aneurysms when employing the electrothermic method of coagulating aneurysms.³

Figure 186 is an x-ray of the heart and aorta taken in slight left anterior oblique position immediately following the direct injection of 70 per cent diodrast. Note the position of the needle in the aorta. The soft tissue shadow outlining the margin of a large *saccular aneurysm*

of the ascending arch can be made out. The distance from the soft tissue margin to the wire seen within the aneurysm represents the amount of clot within the aneurysm before the introduction of wire. Observe the concentration of wire along the lateral wall of the ascending aorta proximal to the aneurysm. Also note diversion of the column of diodrast to the opposite (medial) side of the ascending aorta where, at the level of the aneurysm, the column of diodrast cuts across the mouth of the aneurysm failing to enter the mouth of the aneurysm. Complete, brimful clotting of the aneurysm was interpreted in this case on the basis of the absence of opacification between

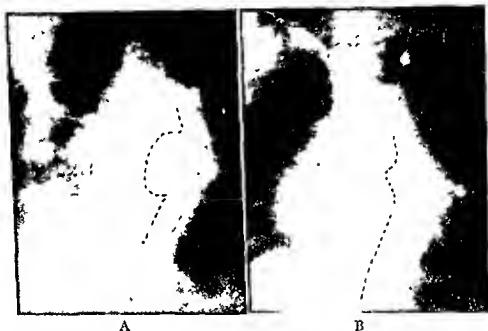


Fig. 187.—*A*, An x-ray of a sacular aneurysm of the descending thoracic aorta taken in the anteroposterior position. Visualization of the aorta and the unclotted portion of the aneurysm was attained following the rapid injection of 35 cc. of 70 per cent diodrast into the aorta through a needle.

B, Another x-ray of the same case following the introduction and heating of more wire in the aneurysm.

the interstices of the wire along the mouth of the aneurysm. The patient died six years later of pneumococcal pericarditis complicating a severe pneumonia. Necropsy revealed complete clotting of the aneurysm. The dotted line noted in the picture was placed as a guide to the margin of the column of diodrast.

Figure 187, *A* and *B*, represents aortograms in a case of *saccular aneurysm of the descending thoracic aorta*. Figure 187, *A*, is an x-ray following visualization of the aorta by diodrast taken at the conclusion of a first stage wiring operation. The dotted line calls attention to the extent to which diodrast entered the mouth of the aneurysm and hence the degree of clotting. Figure 187, *B*, is a diodrast visualiza-

tion of the aorta in the same case made following the introduction and heating of more wire in the region of the mouth of the aneurysm. The dotted line indicating the margin of the diodrast reveals a slight bulge of the diodrast towards the aneurysm but this is very little more than the outward bulge of the aorta wall at the same level directly opposite. We may interpret the above as meaning that the aneurysm following the second stage wiring is approximately completely clotted. Note the outer margin of the wire far away from the aorta indicating the large size of the aneurysm.



Fig 188 An anteroposterior x ray of the abdomen taken following the rapid injection of 35 cc of diodrast into the lower thoracic aorta through a needle. Note the fusiform aneurysm of the abdominal aorta across the upper pole of which courses the diodrast into the renal arteries. The rest of the aneurysm is opacified by wire within it.

Figure 188 is an x ray made following the direct injection of 35 cc of 70 per cent diodrast into the lower thoracic aorta. This patient had a *syphilitic fusiform aneurysm of the abdominal aorta*. The aorta begins to broaden immediately below the origin of the coeliac axis and superior mesenteric arteries. The renal arteries come off the upper third of the fusiform aneurysm. The problem in this case was to obliterate the aneurysm but maintain the renal blood flow. The case was a supreme test for the selective clotting by the electrothermic method. Total occlusion of the aorta distal to the renal arteries was attained in two operative stages approximately three months apart by using a great quantity of wire in the lower pole of the fusiform

aneurysm In the upper pole of the aneurysm just the right number of segments of wire were introduced and heated (based on rate of blood flow measurements) to secure clotting right up to but not including the renal arteries The dotted lines illustrate the diodrast column going out through the renal arteries Opacification by the wire outlines the width of the fusiform aneurysm immediately below Note that the wire narrows down to indicate a normal width of the aorta just proximal to the bifurcation The bifurcation is not visualized by diodrast as evidence of complete obstruction of the



Fig 189—The x ray on the left shows wire coiled in the popliteal space On the right is an arteriogram of the popliteal artery and a fusiform aneurysm of same The injection of 35 per cent diodrast was made directly into the upper pole of the aneurysm

aorta Unfortunately, slight motion on the part of the patient nearly ruined this x-ray The arrow directs one's attention, however, to one very large collateral vessel going down the right side posteriorly It is of interest that this patient has remained totally symptom free nearly seven years since operation For over five years we could not appreciate any pulsation over the femoral arteries He works as a Pullman porter

Arteriography of Arteriosclerotic Peripheral Arteries—Figure 189 presents x-rays of the popliteal region of the legs in an eighty-year-old man The x-ray on the left shows wire in the popliteal space This

represents a two-stage occlusion (the operations were done three weeks apart) of a ruptured arteriosclerotic popliteal aneurysm treated by wiring and electrothermic coagulation. The arteriogram on the right reveals a fusiform arteriosclerotic aneurysm of the popliteal artery of the other leg before the introduction of wire. The aneurysm and with it the popliteal artery were closed off successfully in this instance over a period of three weeks, employing the electrothermic coagulation method in three operative stages. This old gentleman enjoyed the use of both of his legs for some two years until he died of apoplexy. Note the extreme angulation of the popliteal artery just proximal to the aneurysm, and at the level of exit of Hunter's canal. This represents elongation of the arteriosclerotic artery and may be a factor contributing to the frequent history of sudden rupture of arteriosclerotic aneurysms of the popliteal artery. The history of rupture following sudden quadriceps action, as for example, rising from a low seat, squat position or attempted recovery when put off balance with the knees flexed, is common. Sudden violent quadriceps muscle action would tend to rigidify Hunter's canal with perhaps the creation of a "water hammer" effect on the pulse wave which may be transmitted full force, to the tortuous, angulated popliteal artery which lies unsupported in the popliteal space.

Arteriography of arteriosclerotic peripheral arteries should not be dismissed without a word of caution. It should be remembered that all the radiopaque substances employed in angiography are irritating to the vessel wall—some more than others. Though it may be claimed that the irritation is insufficient to cause enough direct damage to the intima to serve as a localizing focus for the initiation of a thrombus, the substances all do cause vasospasm. The latter may, in the presence of arteriosclerotic intimal plaques, be just sufficient to initiate thrombosis in the distal branches of the artery.

Some observers in the early days of angiography suggested the method as an aid in revealing the *adequacy of collateral branches around areas of obstruction*. Arteriography for this purpose is, in my mind, dangerous, and furthermore, because of the superimposed vasospasm, it is not particularly informative. We have other methods equally accurate for determining the adequacy of collateral circulation.

Angiography in Arteriovenous Fistula—Perhaps the most informative and certainly the most interesting application of angiography is in cases of arteriovenous fistula—congenital or acquired. Whereas in congenital fistulas, which are almost invariably multiple, the angiogram may not always show up the actual fistulas, it is nevertheless sufficiently localizing to be an important guide to surgical therapy.

Figure 190 is an angiogram of the hind vessels in a case of congenital arteriovenous fistula in a 74 year old woman. The arteriovenous communications were numerous, localized to the ring finger



Fig 190—In this arteriogram 35 per cent diodrast was injected directly into the brachial artery. Note failure of the ulnar artery to visualize.



Fig 191—An angiogram of the femoral vessels following the injection of 35 per cent diodrast into the femoral artery.

area. The most interesting feature in this case is the exclusive involvement of branches of the radial artery. Though the brachial artery was injected with diodrast, the ulnar artery could not be visualized, indicating a preferential flow through the low resistance fistula circuits connected with the radial artery.

Figure 191 is an angiogram of the thigh in a boy of 11 years with overgrowth of the leg. Whereas in the upper third the femoral artery

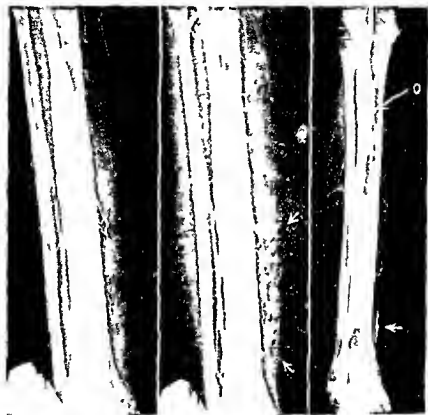


Fig. 192 Arteriograms following the injection of 35 per cent diodrast into the femoral artery.

years after operation

and vein are superimposed owing somewhat to the angle at which the x-ray was taken, lower down the two vessels are separated the smaller being the femoral artery. The two large beaded areas represent fistulous sites—the vein being particularly ballooned at these sites. Some twelve months subsequent to excision of the two fistulas above noted, two bruits were heard—one low behind the knee and the other in the upper calf region. Excision of these has apparently re-

sulted in a cure. Now at 15 years of age there is very slight disproportion in size and length of the legs.

Figure 192 presents arteriograms of the legs in an 11 year old girl. The x-ray on the left is the normal leg. The x-ray in the middle is of the overgrown leg. The x-rays were taken at the same target-tube distance. The arrows in the middle film point to the area involved. Compare the increased vascularity of this area with corresponding area in the normal leg. This case differed from the two preceding cases in that the arteriovenous fistulas were so minute as to cause no audible bruit over the site. The posterior tibial artery was considered to be the feeder to the involved area because it measured ever so little larger than the posterior tibial artery of the normal leg, and because the pulsation over the posterior tibial artery in the involved leg seemed greater than in the normal leg. Because of the companionate system of arterial supply in the leg below the knee we chose a unique if not heroic form of therapy for the eradication of the nest of multiple arteriovenous fistulas in this child. The upper tibial artery and the lower tibial artery were exposed and occluded with a double turn of umbilical tape. Two cubic centimeters of 30 per cent sodium salicylate were then injected into the occluded tibial artery just distal to the proximal occluding tape. Blood flow was reestablished through the artery by removal of the tapes after one minute. Postoperatively vesiculation and superficial ulceration occurred in a port-wine area of the skin overlying the arteriovenous fistula region. After complete healing had taken place and the child was up and about an amazing improvement in the appearance of the soft parts in the affected area had taken place. In addition to considerable reduction in size of the soft part overgrowth the overlying skin, the seat of diffuse capillary angiomas, was no longer blood red in color. Over the period of a year there was progressive reduction of soft part mass and fading of the skin toward normal.

The x-ray on the right in Figure 192 is an arteriogram made approximately two years after operation. This picture unfortunately was taken at a different tube-target distance from the others. The arteries are well outlined, however, and one may note at the arrow O at the upper end of the picture the former site of the posterior tibial artery. The arrow below marks a constricted vestige of the artery. Between these two markers the posterior tibial artery and all its branches, including the arteriovenous fistula area, have been completely wiped out. What arterial branches there are present can definitely be traced across the leg to the well visualized anterior tibial and peroneal arteries.

The exact explanation of overgrowth of the extremities in children having arteriovenous fistula is not known. Whereas the skin temperature difference may be more marked between the normal and the affected limb over the region of the fistulas, usually the temperature is



Fig 194—Arteriogram of the brachial artery demonstrating a patent vein graft anastomosis employing two vitallium tubes



Fig 195—Arteriogram of the femoral artery demonstrating the patency of a vein graft inlay employing vitallium tubes in a restorative endoaneurysmorrhaphy

patency of a vein graft anastomosis of the femoral artery. There is some angulation of the vein graft—a result of redundancy. This is a case of syphilitic aneurysm in which a restorative endoaneurysmorrhaphy was done employing a vein graft inlay mounted on two vitallium tubes. The anastomosis is still patent 8 months since operation.

At this point I wish to call attention to a recent error on the part of Murray and Jones¹ in classifying the Poir method of arterial anastomosis with the nonsuture method of vein graft anastomosis of arteries employing vitallium tubes in respect to the following: "the effect of rigid metal or other material when applied as a circumference around an artery as demonstrated in Poir's clips and more recently in the Blakemore² tubes." To employ my name in the use of vitallium tubes around arteries is a gross misquotation of fact. The reference given in the above quotation is to a recent article by me in which I described and illustrated a nonsuture method of vein graft anastomosis of arteries employing vitallium tubes. We use the tubes on either end of a vein graft. The vein ends are cuffed over the vitallium tubes and are secured by a single fine silk ligature. The vein covered ends of the vitallium tubes are then introduced into the cut ends of the artery, cannula fashion and secured by a holding ligature. From this description and/or reading any one of our five papers on the subject it is apparent that the artery is neither encircled by the vitallium tubes nor in direct contact with them.

In our original communication³ we emphasized the importance of avoiding the use of irritating, nonyielding substances in pressure contact with the artery wall. Vitallium was selected because of its nonirritating qualities and the tubes are so designed that the vein graft funnels gently into the tubes. In our entire experience, both clinical and experimental pressure necrosis of the vessel wall (artery or vein) has never been observed. Furthermore, secondary hemorrhage occurred but once and that in a dog. The hemorrhage in this instance was obviously due to bacterial necrosis about the holding ligature permitting the proximal end of the artery to slip off the vein-covered vitallium tube. Twenty-four hours before the performance of the anastomosis the femoral artery was sectioned and ligated, the wound was left open and no sterile precautions were taken.

A series of vein graft anastomoses using the Carrel suture technic were performed six hours after unsterile section and ligation of the femoral arteries. Only 10 per cent of these anastomoses were successful and secondary hemorrhage occurred in 40 per cent of the experiments. With the combined use of debridement and the sulfonamides both locally and orally, however, the percentage of successes using the vein graft suture technic was boosted to 40 per cent in open, dirty, twenty-four hour old wounds. But in a series of twenty-four hour old, open, dirty wounds the same measures afforded 85 per cent successful anastomoses using the nonsuture vein graft technic.

We did not employ anticoagulants in our experimental work. Our results (40 per cent successes) with vein graft suture anastomoses of dogs' arteries performed through twenty-four-hour-old open dirty wounds are not in accord with those of Murray.⁷ Murray reported 100 per cent failure of vein graft suture anastomosis of the carotid arteries of dogs performed in clean wounds under aseptic precautions when he did not use heparin.

Opportunities to test the efficiency of arterial anastomosis in badly contaminated wounds in peacetime are not abundant. We have been successful with the vein graft vitalium tube technic in the only two cases we have had. Meticulous debridement, chemotherapy, and heparinization were of course employed in these two cases. It would seem from reports of the returning surgeons that heparin (in any form) was not made available for use in blood vessel surgery in our armed forces. Whether the Russians used this valuable adjunct in this war I am not certain. Killian⁸ reporting on a large series of cases in the spring of 1943 makes no mention of heparin. It is of extreme interest, however, that this Russian surgeon operating under the adverse conditions of a field hospital performed seven vein graft anastomoses of damaged arteries employing the suture technic. He describes the results as completely successful in five cases and partly successful in the remaining two cases. Though this Russian surgeon may not have employed heparin, it seems likely that he did use efficient chemotherapy and practically certain that he made a thorough debridement. Furthermore, it is highly probable that his patients received excellent treatment for shock. From any angle the above results are excellent and show what can be accomplished with blood vessel anastomosis in the wounds of modern warfare.

VENOGRAPHY

There are occasions in which venography is extremely useful. I am not in favor of its use, however, in cases of acute thrombophlebitis or phlebothrombosis of the extremities. It seems to me its greatest usefulness is in determining the adequacy of the deep venous system of the leg in old postphlebotic crises. In such cases it may be desirable to strip the great saphenous vein because of varicosities or to do a flap dissection for ligation of the perforating branches.

There may be cases of inferior vena caval obstruction in which it is desirable to know the exact level of the obstruction. Or in cases of obstruction of the great veins in the thorax, venography is useful.

Figure 196 is a venogram showing obstruction of the axillary vein at the level of the border of the scapula. This muscular young man was shoveling gravel from beneath the surface of the water when his shovel suddenly became caught beneath a rock on the up stroke. It seems that the sudden violent contraction of the arm muscles with at the same time holding his breath may have forced blood up from the

arm veins suddenly into the unprotected (from surrounding support) axillary vein. The latter in turn could not empty quickly because of increased intrathoracic pressure, the result being overdistention causing a tear in the intima of the axillary vein. A tear of the intima with



Fig. 196—A venogram of the brachial and axillary veins following the injection of 35 per cent diodrast in the median vein

resulting spasm would form an ideal setting for thrombosis. It is well known however that in many cases of so called traumatic thrombosis of the axillary vein there is no such history of violent muscle effort and forced respiratory arrest.

SUMMARY

Some of the important applications of angiography have been discussed and illustrated. In conclusion it may be stated that techniques of angiography have been achieved to make the method of real value in the diagnosis and treatment of cardiovascular diseases.

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CONGENITAL ARTERIOVENOUS ANEURYSMS OR FISTULAS

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PATHOLOGY

A MOST fascinating subject is a long recognized though relatively rare condition described under various titles such as cirroid or racemose aneurysms, arterial angiomas, and congenital arteriovenous aneurysms. The true nature of the condition, which is an arteriovenous fistula with its sequelae, is not generally understood. Virchow described the lesion nearly a century ago as a mass of thin-walled vessels distended with arterial blood like a pile of pulsating earthworms. Clinically the aneurysm presents itself as a pulsating tumor over which a loud continuous bruit is heard with a stethoscope and a thrill is palpable. These masses connect with large hypertrophied arterial trunks and consist for the most part of thin-walled, dilated, tortuous vessels containing arterial blood under arterial pressure, and emptying directly into the venous system through multiple channels. They occur most frequently in children or young adults. I believe that they are a result of large congenital arteriovenous fistulas, although trauma at times seems to be a factor. They are most common around the head, neck and upper extremity, but may occur anywhere. One of my cases occurred in the lumbar region, another in the buttock.

The condition is progressive and destructive, leading occasionally to the erroneous conclusion that it is a malignant hemangioma. Due to some not well-understood stimulus resulting from the large arteriovenous fistula, there is tremendous increase of all vascular elements. There is real hyperplasia of endothelial and intimal tissues, giving them a microscopic picture similar to a true tumor. Ewing described them as partial tumors. The reason for this growth of vascular tissues is not clear. Some of the extensive progressive venous dilatation and tortuosity may possibly be explained on the basis of the increased pressure in thin-walled veins, a phenomenon similar to the development of extreme varicosities in the lower extremity under the influence of hydrostatic pressure. The whole process is much more complex than that. There is a true overgrowth of endothelial and intimal cells in addition to a very marked hypertrophy of all adjacent vessels and the entire collateral circulation.

The interference with the normal capillary circulation resulting

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from the shunting of large quantities of arterial blood directly into the veins is a factor. Anoxemia with accumulation of the end products of metabolism in the tissues is a great stimulus to increased vascularity. I believe this is the most important stimulus in the development of any collateral circulation. Within themselves, the tissues have some mechanism of adjusting their vascular supply to their metabolic needs. It is my observation that any arteriovenous fistula or aneurysm constitutes the strongest stimulus known to the development of collateral circulation. It is natural that a fistula occurring in the fetal period or at a time of rapid growth and vascular development would show a greater increase in all vascular elements than a traumatic case.

Another phenomenon which may lead to the erroneous conclusion that the process is a malignant neoplasm is their destructive nature. They will invade through muscle, fascia and even bone adjacent to them. I believe this is simply a matter of the arterial pressure within them, a phenomenon shared by all aneurysms.

The dilatation and actual hypertrophy of the afferent arteries proximal to the lesion and the efferent veins is striking. This process is also noted in the traumatic arteriovenous fistulas to a lesser degree. In a case of invasion of the arm the entire subclavian artery was nearly three times as large as the normal subclavian artery on the other side. Even after the fistula has been successfully eradicated, there are often remaining increased local vascularity, accentuated pulse and elevated skin temperature. Perhaps this is all simply a work hypertrophy phenomenon but the exact mechanism of its development is an intriguing problem.

DIAGNOSIS

Differentiation from Malignant Neoplasm—The sharp distinction of all these processes from a malignant neoplasm is important to recognize in order to institute successful treatment. I have seen several of these cases treated by radiation after pathological diagnosis by biopsy of tissue. Radiation will not help this condition and may harm the tissue already suffering from damaged capillary circulation. I have seen very little beneficial effect from sclerosing agents as in the case of capillary and cavernous hemangiomas.

When one considers the embryonic development of the arteries and veins from a common capillary plexus, and the proximity of the large trunks, it is surprising that abnormal communications between them are not more frequent. Small fistulas may be very common. The usual capillary and cavernous hemangiomas may be examples of such fistulas, as claimed by Mont Reid and others. The more one studies the hemangiomas the more attractive this theory becomes.

Clinical Diagnosis—The clinical diagnosis of these cirroid or racemose aneurysms is easy if one is acquainted with the condition. The idiopathic pulsating tumor over which the loud continuous bruit is

heard by the stethoscope is usually enough. The patient is generally a child or young adult. A thrill can be felt as a rule. It is more localized than the bruit, and is the best guide to the exact position of the fistula. The adjacent increased vascularity, the marked dilatation of the veins of the surrounding area, the elevated surface temperature are all usually quite apparent. The tumor is compressible, but will rapidly refill after remove of the pressure. Some of the extremity cases show some embarrassment of the distal capillary circulation even to the point of necrosis and local ulceration but the circulation in most of them has compensated for the difficulty. This varies with the size of the fistula and the development of collateral circulation, as in the acquired traumatic arteriovenous aneurysm. None of these cases in my experience has shown the heart lesions described in large acquired fistulas. Apparently the congenital development gives the heart time for complete adjustment which spares it any damaging effect. Many interesting studies can be made in these cases, such as x-rays after intra arterial injection of radiopaque material, determination of the oxygen content of the venous blood, circulation time, et cetera, but I think they add little to the diagnosis which is certain by much simpler methods.

SURGICAL TREATMENT

Surgical Attack Imperative—The tremendous vascularity of these lesions is very disturbing to the surgeon, but these cases demand surgical attack. The condition is dangerous to life and limb. The process slowly progresses involving a larger and larger area. More and more veins become distended with arterial blood under arterial pressure shunting more and more blood directly from the arterial to the venous system. At the same time the hypertrophy of the vascular tissue elements already mentioned proceeds and the tumor increases in size. The pressure necrosis of surrounding tissues causes more and more trouble, giving rise to nerve, muscle and bone damage. The embarrassment of the normal capillary circulation distal to the lesion is an important consideration. No possibility of normal regression exists. No other treatment is of any avail and suitable surgical treatment *must* be instituted.

Operative Approach—This demands careful study and understanding of the lesion. Attempt at simple surgical excision as of an ordinary neoplasm is almost certain to be a disastrous failure. The innumerable dilated tortuous, thin walled venous channels under full arterial pressure make the control of hemorrhage almost impossible. With every stroke of an instrument, arterial blood spurts forth and there is frequently no definite vessel to clamp and tie in the orthodox manner. Such attempts at *surgical excision usually result in failure*, hasty packing of the wound, repeated blood transfusions and an exsanguinated patient.

Correct Surgical Procedure—Control of the main arterial trunk or trunks to the lesion is essential to successful surgical attack, and they should be exposed before disturbing the pulsating tumor. It is well recognized that *it is dangerous and futile simply to ligate a main artery to an extremity proximal to an arteriovenous aneurysm*. With the distal capillary circulation already embarrassed by the shunt, one is inviting distal circulatory calamity despite a well developed collateral circulation. One of my upper extremity cases had developed gangrene of fingers subsequent to such a procedure. Some of the cases do not present any such problem and the arteries may be tied forth with. A cirroid aneurysm of the lumbar region and another of the buttock are two such examples. Ligation of the afferent arteries and efferent veins accomplished a cure in these two cases with no surgical excision of the tumor in one case, and only partial excision in the other.

In two upper extremity cases exposing the subclavian artery by dividing the clavicle has been a preliminary to a successful surgical approach. Traction by an assistant on a ligature of heavy braided silk passed around the artery has been in my experience a safe and effective way of temporarily occluding the artery. With this precaution and using the location of maximum thrill as a guide, one may be able to trace out the actual fistula. In one of the following reported cases this fistula was from a large branch of the axillary, and the whole process could be safely and easily excised. In another case the subclavian artery had to be ligated, and the whole arm subsequently amputated. This case was a long standing one which had already had extensive tissue damage and partial amputation resulting from incorrect treatment under the impression that the disease was a malignant neoplasm.

REPORT OF CASES

I can illustrate some of these points by briefly summarizing three cases.

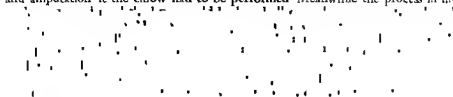
CASE I. A. A. an American born 19 year old daughter of Italian parents first noticed a pulsating lump in her right pectoral region at 13 years of age. She occasionally had dull pain in this region and the lump gradually increased until it was about 10 by 12 cm in diameter. In early 1938 an attempt was made to excise it. The patient states the operation lasted two and one half hours, and that the doctor told her removal was impossible because of very severe arterial hemorrhage.

The patient first came to Memorial Hospital on the service of Dr. George Pick on October 26, 1938. She was admitted for study December 9 to 16, 1938. She presented at that time the findings characteristic of cirroid aneurysms. She had in the anterior pectoral region a 10 by 12 cm pulsating mass with a loud continuous bruit and thrill. The pulses and circulation of the right arm were normal. Pressure on the mass hard enough to compress it would make it almost disappear. Numerous studies were made including an attempt at diodrast visualization, carbon dioxide studies of the venous blood of the two arms, heart tracings, et cetera. Blood aspirated from the aneurysm was arterial in nature but everything else was normal. Diodrast injection was unsatisfactory.

but found it difficult because of scarring from the previous operation. In addition, two large nerve trunks of the lumbar plexus passed directly through it. The wound was closed without further surgery. Bruit and pulsation disappeared at once.

The tumor disappeared and there is no recurrence now, after four and one half years.

CASE III—A third case illustrates some of the difficulties encountered if this condition is not properly understood. This man as a young boy noticed the pulsating tumor in the right neck. He developed marked dilatation of the veins of the arm. Attempts were made to occlude some of these large venous channels by sclerosing agents, and he was given x-ray therapy. Gangrene of the right forearm developed, and amputation at the elbow had to be performed. Meanwhile the process in his



clavian ligation

SUMMARY

Racemose and cirroid aneurysms, arterial angiomas and congenital arteriovenous fistulas are in my experience the same condition.

They present themselves clinically as pulsating tumors in young people over which there is a loud continuous bruit and a palpable thrill. There is a tremendous increase of vascularity in the whole region, and an elevated skin temperature. There is hypertrophy of all vascular elements in pathological section. This added to the progressive course and destructive action by pressure necrosis sometimes leads to a serious error in that they are considered malignant neoplasms.

The lesion is a serious one endangering the life and limb of the patient, and demands surgical cure.

Attempts at excision as of an ordinary tumor are almost sure to culminate unsuccessfully because of uncontrollable hemorrhage.

Successful surgical attack depends upon control of the main arterial trunk or trunks to the lesion. If the involved artery is the main arterial supply to an extremity, simple ligation is apt to result in gangrene, as in the case of traumatic arteriovenous aneurysms. Attempts must be made to eradicate the fistula while the main artery is temporarily occluded. If the blood supply to an extremity is not involved, ligation of the afferent arteries and efferent veins will sometimes cure the lesion without excision of the tumor.

The location of the thrill is the best guide to the location of the fistula. Arteriograms, circulation time and other studies have been interesting but not of much value in treating these cases.

Three cases are briefly reported.

ANEURYSM OF THE ABDOMINAL AORTA

ARTHUR H. BLAKEMORE, M.D.*

PRINCIPLES OF SAFE AND CURATIVE SURGICAL THERAPY

RECENT advances in the surgical treatment of aneurysm of the aorta sharpens the demand for early and accurate diagnosis of aneurysm of the abdominal aorta. Many years of experience with ligations of the abdominal aorta for aneurysm have demonstrated long since the hazards and inefficiency of constrictive occlusion, in continuity, of this great vessel.

Experienced surgeons are fully cognizant of the likelihood of sudden death from hemorrhage due to pressure necrosis of the vessel wall and/or a partial restoration of the vessel lumen following the use of unyielding constrictive agents. Less hope for permanent occlusion of the abdominal aorta follows the use of fascia lita as a ligature material. The latter is prone to stretch and has been known to disappear altogether. A critical review of our total experience with ligation of the abdominal aorta prompted the late Dr. Mont R. Reid¹ to state that, "Partial or gradual occlusion of the aorta by compression (constriction) cannot succeed and should not be attempted. This applies also to the use of partial constrictions proximal to a totally occluding ligature."

Dr. Mont Reid was the first to demonstrate experimentally that the dog's aorta could be occluded in continuity without interference with the circulation of the vessel wall. This he accomplished successfully by the introduction of a fascial plug into the lumen of the aorta, transfixing it to the vessel wall by through and through mattress sutures. This investigation was an important contribution because it served to introduce the principle of endoarterial occlusion. The limiting factor in the clinical application of the method is the dangers of a one-stage occlusion of the aorta.

Brooks, Blalock and Johnson,² and others have pointed out that the immediate mortality and incidence of gangrene is so high in humans as to preclude the use of a one-stage occlusion of the aorta. Granted that in the occasional case of a very large aneurysm of the abdominal aorta arising distal to the renal arteries, the stimulus to the development of collateral circulation may be adequate to support a one-stage occlusion of the aorta proximal to the aneurysm. But, the very seri-

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ous question arises whether a collateral circulation of such briskness would not also insure the activity and subsequent growth of the aneurysm. Whereas, pulsation in the aneurysm may cease following operation, as time goes on the diastolic blood pressure in the aneurysm will tend to approximate the systolic level in the aorta proximal to the occlusion and with it a return of the factor of strain upon the aneurysm sac. The briskness of the collateral blood flow through the aneurysm would prevent complete obliteration of the sac by clot and, in time, the growing aneurysm would be subject to the vicious circle of increased strain upon a sac wall of diminishing strength. The identical hemodynamics would, of course, obtain in a two or more stage occlusion of the aorta.

Granted that proximal ligation may greatly retard the rate of growth, the above cited facts bring to us the realization that the only safe and certain curative treatment for aneurysm of the abdominal aorta embraces a two stage endoarterial occlusion of the aorta proximal to the aneurysm with obliteration of the aneurysm sac. Such a treatment for aneurysms of the aorta arising distal to the renal arteries is now an accomplished fact employing a wiring method of endoarterial occlusion with obliterative electrothermic coagulation of the aneurysm. The method has proved equally successful for arterio-sclerotic or syphilitic aneurysms of the fusiform or saccular variety.³

Pathologists, over the years, have exhorted us against the explosive danger of the expanding abdominal aneurysm. Yet where is the doctor who has not, sometime in his career, stalked a case through a period of growth and contemplative horror until the end. Early diagnosis and charting of the behavior of the aneurysm now offers fresh hope when there is yet hope.¹

RUPTURED ANEURYSM WITH RETROPERITONEAL HEMORRHAGE

The ease with which the diagnosis of some aneurysms of the abdominal aorta are made and yet the difficulty in others is in the words of Osler, "conducive to clinical humility." There is, for example, no disease more capable of precipitating a diagnostic dilemma upon the unwary surgeon than a "leaking" abdominal aneurysm. The signs and symptoms of spreading retroperitoneal hemorrhage are often confused with acute intraperitoneal or even kidney conditions.

Karabin⁴ has made an excellent presentation of the symptomatology of retroperitoneal hemorrhage in an analysis of nine cases. It is of interest that the hemorrhage was due to ruptured aneurysms of the abdominal aorta in seven of the nine cases. It is of further interest that, though the diagnosis of aneurysm had been made, four of the seven cases were explored because in addition an acute intraperitoneal condition was suspected. All seven cases had sudden onset of severe abdominal pain. The pain was often generalized and colicky or local

ized to either side in the lower abdomen. Back pain was a frequent complaint and often the pain was referred into the legs. Severe vomiting was frequently present. The abdomen was tender and rigid at the onset but the rigidity usually diminishes with the onset of ileus twenty-four hours to five days later. At varying intervals of a few minutes to several hours after onset of the pain the patient feels faint and collapses. During collapse there is usually marked pallor. The blood pressure may be extremely low and the pulse rate rapid. In most instances an abdominal mass is palpable in which usually, but not always, pulsations can be detected. Sometimes a bruit is heard over the mass. In the seven cases of ruptured aneurysm of the abdominal aorta reported by Karabin the average age was 70. Generalized arteriosclerosis was present in all seven cases and was considered to be the etiological agent.

It is of extreme interest to note that the duration of life following the onset of hemorrhage in Karabin's seven cases of ruptured arteriosclerotic aneurysms of the abdominal aorta averaged three to four days. This is also in accordance with our own experience. One is not likely to appreciate the full significance of this because we are accustomed to associate rupture of an aneurysm with immediate exitus of the patient since it so regularly follows in cases of aneurysm of the thoracic aorta—the more common variety. Whereas the explanation of this difference in clinical behavior is conjectural, its importance is tremendous and no doubt accounts for the fact that we are now able to save some of these cases of "leaking" aneurysm of the abdominal aorta by early operation.

EARLY SIGNS AND SYMPTOMS IN THE DIFFERENTIAL DIAGNOSIS OF ARTERIOSCLEROTIC AND SYPHILITIC ANEURYSM

In order that a greater number of growing aneurysms of the abdominal aorta may be offered surgical care at a time more favorable to success it would seem worthwhile to review the early symptoms and signs upon which the diagnosis of aneurysm may be suspected.

In search of early signs and symptoms an analysis of twenty-three cases of aneurysm of the abdominal aorta admitted to the Presbyterian Hospital was made. Syphilis was considered to be the etiological factor in five of the twenty-three cases. The average age of the five patients was 43 years. Arteriosclerosis was considered the cause of the aneurysm in the remaining eighteen cases. The average age in the arteriosclerotic group was 63 years. In the latter group there were two females.

Analysis of the syphilitic and arteriosclerotic cases was of interest in relation to the *level of origin* of the aneurysms in the abdominal aorta. In the syphilitic group of five cases the aneurysms arose above the renal arteries in four. In one case the renal arteries came off the fusiform aneurysm sac. In four of the five cases the aneurysms were

end, the site of its bifurcation into the common iliac arteries. With these anatomical facts in mind the abdominal aorta when it undergoes elongation due to arteriosclerosis must, of necessity, deviate from its normal course along the anterior aspect of the lumbar spine slightly to the left of the midline. The elongated arteriosclerotic abdominal aorta invariably deviates anteriorly a short distance below the diaphragm usually just below the origin of the renal arteries. This anterior deviation is so marked that it is not uncommon to see sizable fusiform aneurysms well anterior to the lumbar spine as demonstrated by x-rays taken in the lateral position. Anterior displacement undoubtedly contributes to the likelihood of palpating a pulsating mass and would seem to account for the rarity of vertebral erosion in cases of arteriosclerotic aneurysm of the abdominal aorta. As would be expected with the elongated arteriosclerotic abdominal aorta, deviation to the right or left also occurs. It is not uncommon, for example, to encounter a large arteriosclerotic fusiform aneurysm of the abdominal aorta presenting anteriorly and to the right of the lumbar spine. An exaggerated left position of the aneurysm is, however, more common.

The x ray is an important aid in the diagnosis of arteriosclerotic aneurysm of the abdominal aorta. Though vertebral erosion was extremely rare in our series (occurring but once in eighteen cases), properly taken x rays will almost invariably enable one to outline the aorta and aneurysm by visualization of calcium plaques in the vessel wall and aneurysm sac and often calcified laminae within the sac may be visualized.

A review of the eighteen cases of arteriosclerotic aneurysm of the abdominal aorta reveals that the correct diagnosis was made in sixteen of the eighteen cases, and the clinical behavior was such that fourteen of the eighteen cases came to grief either from rupture of the aneurysm (seven cases) or the development of intolerable symptoms from the aneurysms. The diagnosis was confirmed by necropsy (eleven cases) or surgical exploration (four cases).

PROGNOSIS

A review of any substantial series of abdominal aneurysm in general reveals the disease as one in which death may be expected soon after the onset of symptoms. Kampmeier⁵ in a study of seventy-three cases of aneurysm of the abdominal aorta revealed that the majority of the patients succumbed within six months after the onset of symptoms. Death was due to rupture of the aneurysm in the majority of the cases (thirty-one of thirty-eight cases necropsied). Nixon⁶ reviewed a collection of 233 cases of aneurysm of the abdominal aorta in which the incidence of death from rupture was 65 per cent.

Our impression of the prognosis in cases of *arteriosclerotic aneurysm of the abdominal aorta* is likely to be somewhat distorted for the following reasons (1) The symptom of pain may be absent or

minimal for a longer period of time after the onset of the aneurysm than we are accustomed to observe in cases of abdominal aneurysm due to syphilis because of the extreme rarity of vertebral bone erosion. (2) The incidence of death from other causes during the interim is so much higher in cases of arteriosclerotic aneurysm when compared to syphilitic aneurysm of the abdominal aorta, which average twenty years younger. A review of Karabin's case reports and the clinical behavior of the eighteen cases of arteriosclerotic aneurysm of



Fig 197.—An x-ray of a wired fusiform, arteriosclerotic aneurysm of the abdominal aorta. Note the densely packed wire placed for obstructive purposes in the aorta just proximal to the aneurysm.

the abdominal aorta previously discussed should dispel any doubt as to the malignancy of the arteriosclerotic aneurysm of the abdominal aorta.

In a given case of arteriosclerotic aneurysm of the abdominal aorta in which there is x-ray proof of expansion of the aneurysm, or the sudden appearance of pain, whether it be backache or combined lumbar and abdominal pain, are warnings of impending disaster. As has been previously emphasized, patients with arteriosclerotic aneurysm

DIAGNOSIS OF PERINEPHRIC ABSCESS

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CORRECT evaluation of the history, physical signs, laboratory data and x ray findings should lead one to the diagnosis of perinephric abscess in the majority of instances. However, the diagnosis is often missed because of reliance upon the radiologic picture, if it has not been correlated with the symptoms and signs.

Etiology.—A large percentage of perirenal infections seen in urologic practice occur secondary to renal disease, such as calculus, renal carbuncle and pyonephrosis. *Staphylococcus aureus* and *Escherichia coli* are the most frequent bacteria found although the streptococcus, *Bacillus proteus*, *Bacillus pyocyaneus* and the *Aerobacter* group may be etiologic factors.

History.—Carbuncles, furuncles and even superficial skin infections are frequently the source of infection when *Staphylococcus aureus* is the infectious agent. Invasion of the renal cortex or the perirenal tissue is considered metastatic from the blood stream. Colon bacilli may gain entrance to the kidney from the bowel by way of the lymphatics but most frequently these organisms are found secondary to ureteral obstructions and calculus. Streptococcus abscesses may occur following dental, tonsillar or sinus infections. The so called nonpathogenic bacteria, *Bacillus proteus*, *Bacillus pyocyaneus* and *Aerobacter aerogenes*, invade the kidney following retrograde cystoscopy, ureteral catheterization and renal surgery.

Symptomatology.—The first symptoms noted are malaise and loss of appetite usually accompanied by fever. Fever may be low grade or intermittent and, when pyelonephritis is present, markedly elevated and spiking.

Pain may not be present during the onset of illness. There is nothing typical about the pain. Backache, aching in the side or severe pain localized at the costovertebral angle is usually noted. Later, pain radiated to the groin, hip, thigh or over the fascia lata may be present. Pain on walking, especially on extension of the thigh, is frequent. Psoas spasm is demonstrated by this symptom. Pain referred to the chest with respiratory symptoms may cause the patient to be admitted for medical treatment.

Urological symptoms such as frequency, urgency and dysuria are

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conspicuously absent unless the perinephric infections occur secondary to urolithiasis, pyelonephritis or urologic surgery.

Physical Examination—Patients with perinephric abscess frequently prefer to lie with the thigh flexed. Some appear acutely ill while others appear in good physical condition.

Dyspnea, signs of diaphragmatic irritation, atelectasis or findings consistent with atypical pneumonia may be found especially when the lesion is at the upper pole of the kidney.

There is usually costovertebral angle pain and tenderness on the affected side. A mass may bulge the flank or a palpable although sometimes indefinite mass is felt in the region of the lower pole of the kidney. Gaseous abdominal distention may be present.

Psoas spasm can frequently be demonstrated. This is not a constant finding and may be present intermittently.

The temperature is usually elevated, higher in coccic infections than in bacillary types. Pulse and respiration rates are elevated.

Laboratory Data—A mild to moderate secondary anemia is common. The white blood cell count is regularly elevated averaging about 13,000.

Urinalysis is frequently entirely negative. After long standing infection albumin may be present. Obviously, perirenal abscess secondary to ascending urinary tract infection supports the finding of pyuria and occasionally hematuria.

The sedimentation rate is regularly elevated.

Urine cultures obtained from voided specimens or from urethral or ureteral catheterization are quite regularly sterile in cases of staphylococcus abscess. Bacillary abscesses frequently are accompanied by positive urine cultures.

X-ray Data—Chest films may show evidence to support the diagnosis of atelectasis or atypical pneumonia.

The flat film of the abdomen may show curvature of the spine toward the affected side. The psoas muscle shadow may be obliterated, bulged outward or may appear normal. Obliteration of the psoas shadow along the border of the muscle is not a constant finding. The renal shadow may or may not be distinct.

Pyelograms made either by the intravenous or retrograde method are most difficult to interpret. The diagnosis of renal cortical tumor or renal cyst is frequently made because of distortion or obliteration of calices. The kidney may be pressed or drawn out of normal position by the abscess. Occasionally, the radiologist points out compression of the kidney by a perirenal mass. *The only constant x-ray finding in perinephric abscess is fixation of the kidney.* For this reason, upright films should be made in suspected cases. I prefer to have them made routinely in pyelographic studies.

CASE REPORTS

The following cases are recorded to demonstrate the difficulty of diagnosis. Incision and drainage were delayed in all but one case because of failure properly to evaluate the symptoms, signs and x-ray findings earlier.

CASE I—This officer, 49 years of age, was admitted on March 10, 1944, to the Medical Service of Walter Reed General Hospital because of backache, fever and chills of ten days' duration with the tentative diagnosis of atypical pneumonia. During the first week of his illness he had malaise, marked loss of appetite and low grade fever, but he was able to carry on. During the second week he was confined to quarters. On physical examination an area of dullness was noted in the left lung base. Breath sounds were diminished and there were moist crackling rales over that area. The physicians noted that no masses or areas of tenderness were present over the abdomen, the liver, kidneys and spleen were not palpable. Laboratory studies showed red blood cells 3,800,000, leukocytes, 11,400, hemoglobin, 80 per cent, polymorphonuclears 89 per cent. The Kahn reaction was negative. The urine was clear and acid in reaction. There was no albumin or sugar, an occasional white cell was found.

The patient was given sulfadiazine. Two days later the urinalysis was negative. The sulfonamide blood level reached 82 mg per 100 cc. The pneumococcus was not recovered from cultures. The x ray report stated "The atelectasis at the left base is consistent with atypical pneumonia." On March 18, x ray of the chest showed normal lungs except for a small area of residual atelectasis at the left base. The patient's temperature returned to normal after eight days of sulfadiazine therapy. Following the discontinuation of medication, he began to have fever again. There was still bronchial breathing with rales to the left base, posteriorly.

On March 24 the patient began to have vague left upper abdominal pain. Examination by the physician revealed an indefinite, rather large mass in the left abdomen, which did not move with respiratory movements. The mass was not particularly tender. In an x ray film of the abdomen the left kidney shadow was poorly defined, but appeared markedly enlarged. The right kidney shadow was not seen. Psoas shadows were visible with slight prominence of the left psoas muscle, probably due to slight rotation of the patient. The x ray consultant concluded, in view of these findings, that "the atelectasis of the left base is probably due to subdiaphragmatic inflammation."

Urological consultation on March 26, 1944 revealed that the patient had had backache, particularly on the left side. There had been no definite pain on movement. The patient had no symptoms referable to the bladder or urethra, no pain or swelling of the testicles, no rectal or perineal pain. Examination revealed tenderness at the left costovertebral angle and a mass in the left flank, which was not movable and did not bulge out in the flank. The right kidney was not tender to palpation. No hernia was present and the external genitalia were normal. The tentative diagnosis of perirenal abscess was made and intravenous urography revealed both kidneys enlarged and calices distorted, the appearance suggesting polycystic disease. The right kidney was low in position and descended when the patient was placed upright. The left kidney was in normal position but fixed. The left psoas shadow was still intact though prominent. This latter finding was against the presence of any extensive perinephric abscess. Fixation could be due either to a localized abscess or a renal carbuncle with adhesions.

Cystoscopy and urography were carried out on March 31, 1944. The bladder appeared normal. Number 6 catheters were passed up to the kidney pelvis on each side. The urine was scanty. The phenolsulfonphthalein test showed appear



Fig 198—Roentgenograms showing perinephric abscesses

A The abscess is on the left side. *Staphylococcus aureus* was cultured from the abscess. Note lumbar kidney, right obliteration of psoas shadow, compression of lower calices on the left, hazy renal outline. The kidney is fixed (Case I).

B Left perinephric abscess. *Staphylococcus aureus* was cultured from the abscess. Note partial obliteration of psoas shadow, compression of lower calices, hazy renal outline. The kidney is fixed (Case II).

C Right perinephric abscess of *Staphylococcus aureus* or gon. Note obliteration of psoas shadow, axial rotation of kidney and hazy renal outline. The kidney was drawn downward by the infection which involved the psoas muscle and to a lesser extent the lower pole of the kidney (Case III).

D Right perinephric abscess. Note obliteration of psoas shadow, axial rotation of kidney and hazy renal outline. The kidney was drawn downward by the infection which involved the psoas muscle and to a lesser extent the renal tissue (Case IV).

ance in four minutes with excretion of 17 per cent on the right side and 3 per cent on the left in fifteen minutes. Ten cubic centimeters of skiodan were injected into each kidney pelvis and pyelograms (Fig 198 A) demonstrated a congeni-

tally short right ureter The superior left calices appeared more irregular than the inferior ones The remaining calices were not well filled and appeared

tures of urine from the bladder

diagnosis Perinephric abscess, left

On April 6, 1944, incision and drainage of the perinephric abscess on the left was carried out Cultures of the purulent material from the abscess showed *Staphylococcus aureus* A course of penicillin therapy was given The patient improved rapidly He was discharged from the hospital on May 13, 1944

CASE II—This 24 year old soldier was admitted to a Station Hospital, June 30 1943, because of chills, fever and malaise, occurring at the end of a long walk. He had headache, vague aches and pains, but no localizing symptoms The patient had had carbuncles on his buttocks several weeks previously His temperature was 101° F Physical examination was quite negative There were no masses in the abdomen There was no costovertebral angle tenderness Neither kidney was enlarged or tender, and urinalysis on admission was negative The patient ran an intermittent type of fever He was given sulfadiazine The blood findings were red blood cells, 5,150,000, leukocytes, 10,000, with 65 per cent polymorphonuclear cells Four days later the urine showed a few white blood cells and red cells, which were considered to be due to the sulfadiazine Therapy was changed to sulfathiazole The patient continued to run a low grade fever and developed pain in the left flank He was transferred to Walter Reed General Hospital on July 18, 1943

There was some decrease in breath sounds over the left lower chest posteriorly No rales were heard There was some dullness to percussion The Medical Officer felt that the case was possibly one of residual atypical pneumonia Examination of the abdomen revealed marked tenderness over the entire left lumbar region and at the left costovertebral angle There was fixation of the pelvis, and hyperextension of the left leg increased the patient's pain—evidence of psoas spasm On the following day there was no evidence of psoas spasm The patient was treated for atypical pneumonia and not until August 4 did he have any repetition of the psoas spasm, which was fairly marked on that date On August 6 he continued to have psoas spasm and x rays showed definite obliteration of the psoas shadow No masses were definitely palpable

Urological examination note on August 8, 1943 'This soldier has had a series of carbuncles On July 5 he developed pain in the left flank with pain in the left leg There was no history of typical renal colic or passage of gravel, stone or blood The patient has had a low grade fever He has had no symptoms referable to the bladder or external genitalia The patient was lying on the table with the left leg flexed and the right leg extended There was a bulging mass in the left flank with definite tenderness at the left costovertebral angle There was a large soft tissue mass palpable almost to the midline The kidney itself could not be felt There was no right costovertebral angle tenderness The right kidney was normal Marked psoas spasm on the left **Diagnosis** Psoas abscess Intravenous urograms are suggested to confirm the diagnosis'

Repeated urinalyses showed not more than 1 or 2 white cells per high power field Blood and urine cultures were sterile Intravenous urography (Fig 198, B) revealed slight right lumbar scoliosis and the right psoas muscle was more distinct than the left Both kidney outlines were visible There were no definite abnormal soft tissue masses The left kidney was slightly lower than the right There was no deformity or displacement of the ureters The kidney pelves and calices were not remarkable Further x ray studies showed the left psoas shadow indistinct in outline The soft tissue to the left of the lumbar spine was more prominent

than could be explained by scoliosis. The left kidney moved very slightly by change in position of the patient. All of these changes strongly favored psoas abscess.

On August 17, 1943, incision and drainage of psoas abscess was carried out. Cultures from this abscess showed *Staphylococcus aureus*. The patient made an uneventful recovery and was returned to duty following sixty days in the reconditioning program.

In this case the diagnosis of perinephric abscess involving the psoas muscle was made by history and physical examination. X-ray studies confirmed the diagnosis of psoas abscess, however, no lesion of the kidney was demonstrated until surgery was performed.

CASE III—This 36 year old soldier was admitted to his Station Hospital on July 27, 1943, complaining of indigestion of three weeks duration, anorexia, loss of weight (10 pounds in ten days), diarrhea for ten days, pain and soreness in the right side of his abdomen.

Physical examination revealed a rather thin man. There was a papular eruption on the right forearm, wrist and left hand. The entire right side of the abdomen was rigid. There was a definite mass about 4 inches in diameter extending below the costal margin but not out in the flank. This area was quite tender. There was no costo-vertebral angle tenderness and Murphy's sign was negative. The patient had had no urinary symptoms. Urinalysis was negative. White blood cells numbered 10,800 with 81 per cent polymorphonuclears; the hemoglobin was 94 per cent. Culture from the lesions on the patient's hand and forearm showed *Staphylococcus aureus*. Blood culture was negative. X-ray studies showed lung fields clear. A flat film of the abdomen showed a large mass extending down to the region of the crest of the ilium on the right side, obliterating the psoas shadow. The colon was outlined by opaque material and there was noted displacement of the hepatic flexure and of the transverse colon. Barium enema showed no intrinsic lesion of the colon. A gastrointestinal series showed no organic lesion of the stomach or duodenum. The lower half of the second portion of the duodenum was displaced to the left. Intravenous pyelography revealed dye present in both kidneys in five minutes. The left side was normal. The right kidney shadow was obscured with obliteration of the psoas shadow, apparently secondary to a large mass in this region. The calices were blunted and there was dilatation of the renal pelvis. Pyelographic studies (Fig. 198 C) strongly suggested the presence of an extrinsic mass exerting pressure on the kidney, although tumor of the right kidney could not be ruled out.

The patient was transferred to Walter Reed General Hospital and admitted to the Surgical Service on July 30, 1943. Examination was as noted previously. A diagnosis of right perinephric abscess was made.

The patient was transferred to the Urological Section and a large abscess involving the lower pole of the right kidney and the entire belly of the psoas muscle was drained on August 5, 1943. On October 11 the patient was transferred to the Convalescent Section for reconditioning and eventually was discharged to duty.

CASE IV—This 45 year old woman was admitted to the Medical Service, Walter Reed General Hospital, on January 18, 1943, complaining of pain in the right upper quadrant of the abdomen radiating down from the flank to the right groin, of two weeks duration. The pain was a continuous ache. There was never typical renal colic. During the first week of her illness she had loss of appetite and felt badly but continued with her work. During the second week the pain became very severe, her temperature reached 101° F. but there were no chills. She had no nausea or vomiting. She took very large quantities of water and there was more frequency of urination. She had had no pain or discomfort on urination.

The urine, examined by her physician on January 13, was negative. Her fever continued and her pain persisted.

General physical examination showed no abnormalities. Palpation of the abdomen revealed no distention. There was no muscular rigidity. The liver edge was not definitely palpable. A globular mass not very definite was palpated in the region of the right kidney, which was slightly tender. There was no costo-vertebral angle tenderness. Pelvic examination revealed a moderate cystocele and rectocele. Urinalysis was entirely negative. The blood findings were red blood cells, 3,900,000; leukocytes, 13,650; hemoglobin 70 per cent polymorphonuclears 84 per cent. The urine was sterile on culture. The Kahn reaction was negative. The sedimentation rate was 27 mm. in sixty minutes. A tentative diagnosis of cholecystitis was made.

Urological consultation on January 20 noted history as above. There was no

the right kidney being lower in position than the left. The gallbladder was faintly visualized after the Graham dye. The radiologist suggested reexamination of the gallbladder by the intravenous method and right retrograde pyelography because of the unsatisfactory intravenous pyelogram. Cystoscopy on January 29 revealed a perfectly normal bladder. Number 6 catheters were passed to the renal pelvis on each side; the urine was grossly clear. The phenolsulfonphthalein test showed appearance time of two and one half minutes on each side. 70 per cent excretion from the right in fifteen minutes; 15 per cent from the left. Pyelography was carried out, using 10 cc of skiodan on each side. These films (Fig 198, D) showed the left kidney to be normal, the right kidney apparently enlarged at the lower pole. The pelvis was distorted and the calices especially in the lower pole were displaced upward in a bizarre fashion suggesting pressure by a space taking lesion of the lower pole. The findings were consistent with right renal tumor. Pyelography was repeated taking both anteroposterior and lateral films. The appearance of the right kidney was as previously described. The radiologist's note was "Findings could be produced by either tumor or cyst, but I believe tumor is more likely." Cultures of urine from the bladder and from both kidneys were sterile; no pus in any of the specimens. Repeated study of the gallbladder showed some reduction in size but no abnormality. A gastro-intestinal series was negative as were x rays of the lumbosacral spine and pelvis. The urologist was of the opinion that the defect of the lower pole calices was congenital and not due to tumor.

The patient's temperature was normal by February 11. She began to complain of pain over the lateral surface of the right thigh over the fascia lata. She limped slightly and was unable to straighten out the right leg, except with pain. The mass in the region of the lower pole of the right kidney had apparently increased in size. Operation was performed on February 23, 1943, scheduled as "exploration of right kidney." An incision was made from the costo-vertebral angle downward and forward to a point just above the anterior superior spine of the ilium. The muscles were sharply divided down to the perirenal space. The fascia of Gerota was opened. An inflammatory reaction was noted around the lower pole of the right kidney, extending posteriorly into the body of the psoas muscle. A large portion of this entire inflammatory mass was excised from the belly of the psoas muscle, leaving very little inflammatory tissue at the lower pole of the right kidney. Very little pus was encountered. The kidney had been retracted downward by the abscess involving the psoas muscle and held there by inflammatory tissue. The tissue removed at operation showed chronic inflammatory reaction. Cultures showed no growth in forty-eight hours. The patient made an uneventful recovery and has been perfectly well for the past two years.

CASE V—This Flight Officer was transferred to Walter Reed General Hospital with the diagnosis of right renal tumor. He had had a febrile illness with exacerbations of chills and fever over a period of two years. He had no symptoms suggestive of urinary tract infection. There had been no nocturia, frequency, urgency or difficulty, no pain or burning on urination except associated with



Fig. 199 (Case V)—Roentgenograms of patient having a renal tumor.

Note distal

1945 shows

film shows absolute fixation of the right kidney and normal ptosis of the left.

acute neisserian infection which was treated by penicillin and cured. Reviewing the history I find that he had carbuncles. There had been very little pain in either flank. During acute episodes of fever he did have some discomfort in the right upper quadrant of the abdomen but this has not been severe. He had no hematuria.

On admission, he complained of general malaise and of a little fever in the evenings as high as 99° F. He had no urological symptoms.

Examination revealed a rather pale, thin man. There was no definite costo vertebral angle tenderness. A mass was palpable in the right upper quadrant of the abdomen which felt like the lateral border of the kidney rotated anteriorly. There was a rather sharp edge to this mass which was not movable. The left kidney was not enlarged or tender, and there was no lower abdominal tenderness. Hernia was not present. The external genitalia were perfectly normal. By rectal examination the prostate and seminal vesicles and base of the bladder were found to be normal.

Review of x rays shows that in November, 1944, pyelography (Fig 199 A) in Germany showed narrowing of the upper calices of the right kidney. The middle and lower pole calices were normal. The outline of the kidney at that time was within normal limits. Certainly, from that pyelogram, diagnosis of right renal cortical tumor would have been justified. The left kidney appeared to be perfectly normal.

Films taken at the Oliver General Hospital by retrograde and intravenous methods (Fig 199, B) show that there has been a marked increase in size of the mass involving the upper pole of the right kidney, and in those films all of the calices were turned forward and apparently compressed. There was no blunting of any of the calices. This suggested a mass occupying the cortex of the kidney.

The deformity of the calices of the kidney does not usually increase in size at this rate and with the history of fever, one would have to consider the possibility of an infected solitary cyst.

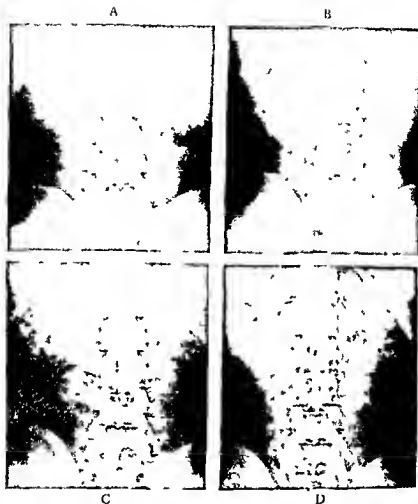
The preoperative diagnosis was Cyst renal right, infected Carbuncle of the kidney cannot be ruled out. The radiologist at Walter Reed General Hospital made a diagnosis of perinephric abscess because of the presence of air in the mass. The right kidney was fixed in position (Fig 199 D).

Incision and drainage of perinephric abscess at the upper pole of the right kidney was done September 18, 1945. About 1000 cc. of light green pus was evacuated and the cavity packed. Convalescence was uneventful.

CASE VI—This 27 year old soldier, inducted May 6, 1943, had left ureteral colic in June 1943, accompanied by urgency and frequency. He was treated for left sided pain at his station hospital in June. October and November 1943. The stone was visualized and the ureteral catheter passed an obstruction at 3 cm. on July 2, 1943. The catheter was left in place for drainage on July 6, 1943. On July 12, 1943 the stone was no longer visible. In October the patient developed right renal pain with percussion tenderness over the right kidney. He had acute cystitis and bilateral pyelitis. Because of poor response to sulfonamide therapy, he was transferred to Walter Reed General Hospital on November 27, 1943.

Examination showed slight right costovertebral tenderness and a mass in the right upper quadrant 10 cm. in diameter. A definite psoas spasm was present on the right. Urinalysis showed many white blood cells, albumin 2 plus, sugar, negative, and urine culture demonstrated *Staphylococcus albus* and *Streptococcus faecalis*. Blood findings were: red blood cells 4,450,000; leukocytes 16,000; hemoglobin 90 g/l.

Firmly diagnosed as perinephric abscess. Review of x ray film confirmed diagnosis. Right kidney appeared normal in June films. November examinations the upper calyx and superior pelvis of the right kidney were displaced laterally (Fig 200 B). The findings and rapidity of growth suggested to the radiologist the diagnosis of abscess or rapidly growing tumor. Retrograde urograms on November 26, 1943, showed (Fig 200 C) more marked deformity but the diagnosis of abscess was established by the findings of diaphragmatic irritation and acute febrile reaction suggesting rupture of the renal carbuncle and perinephric invasion. Incision and



C

D

Fig 200 (Case VI) —Roentgenograms of a patient having a perinephric abscess secondary to a renal carbuncle on the right. *A*, Pyelogram (June 26, 1943) showing hydronephrosis on the left secondary to calculus. The right side appears normal. *B*, Pyelogram (October 17, 1943) showing deformity of the right kidney due to a mass on the medial side of the upper pole causing rotation of the kidney. The renal outline is indistinct. The psoas shadow is noted below the kidney outline. The diagnosis of tumor would be justified from examination of this film alone. *C*, Pyelogram (November 26, 1943) showing increase in size of the lesion deforming the upper pole of the kidney and causing rotation. The diagnosis of carbuncle was made from correlation of the symptoms, signs and radiographic evidence. *D*, Pyelogram (December 20, 1943) made four weeks after drainage of the perinephric abscess and of the renal carbuncle, shows the persistent deformity but also a definite tendency toward normalcy.

drainage of the perinephric abscess and carbuncle were carried out on November 26, 1943—a 4 inch paravertebral incision was used. One hundred cubic centimeters of pus was evacuated posterior to the kidney. Further exploration opened the renal abscess and more than 100 cc of pus was evacuated. Drains and tubes

were placed. The patient had an uneventful convalescence. Postoperative films show return toward normal (Fig 200, D). On January 11, 1944, left ureterolithotomy was performed and the patient was sent on February 14, 1944 to a convalescent facility for reconditioning.

SUMMARY

Cases I and II illustrate the difficulty of early diagnosis because of the predominance of symptoms and signs of pulmonary disease.

Cases III and IV illustrate a difficult problem in x-ray diagnosis. The axial rotation of the kidney caused by contraction of the abscess with scarring in the late stages produces the "mouse-like" deformity of the pyelogram. The kidney is not displaced by pressure of the abscess but rather is retracted by the scar involving the psoas muscle as well as the lower pole of the kidney.

Cases V and VI illustrate the development of the renal carbuncle followed by rupture and perinephric abscess.

As pointed out by Mathe in 1933, absolute fixation of the kidney is the only constant x-ray finding in perinephric infection. This is best shown by obtaining upright films with the patient at full inspiration.

PHEOCHROMOCYTOMA OF THE ADRENAL GLAND

A Report of Two Cases with Operative Removal of the Tumor

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PHEOCHROMOCYTOMAS are tumors of the chromaffin system and as such represent one of the subdivisions of the class of the hormonal tumors which produce a typical symptomatology dependent on the type of hormonal substance elaborated. In the case of the pheochromocytomas this substance is adrenalin or some product very closely related to it. Thus the syndrome represents the response of the body to the introduction into the general circulation of massive quantities of adrenalin.

These chromaffin tumors may arise either from the adrenal medulla or from chromaffin tissue located elsewhere in the body, namely, from the paraganglia of the sympathetic nervous system, or from a strip of chromaffin tissue ventral to the abdominal aorta and superior to the inferior mesenteric artery or in the organs of Zuckerkandl on either side of the aorta at the origin of the inferior mesenteric artery and finally in the carotid body. Thus they may be intra or extra adrenal in location.

They occur infrequently. Up to 1940 Brunschwig and Humphreys¹ collected a total of ninety cases from the literature and since then an additional thirty instances have been recorded. Of these approximately forty cases were clinically recognized and treated by operation.

About 19 per cent of the reported cases showed bilateral involvement of the adrenals and in all instances where bilaterality occurred the tumors proved to be malignant.

The tumor being usually benign is well encapsulated. It occupies the medullary portion of the gland and is covered in part by a narrow rim of cortex. The size varies from 1 to 12.5 cm. The tumor may undergo various types of degenerative changes such as hemorrhage and necrosis which tend to give it a cystic character. The benign tumors show no tendency to invade either the medulla or the cortex but rather to compress these areas which are demarcated from the tumor.

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mass by a well defined capsule. Microscopically, the benign tumor is highly cellular. It consists of islands of large polyhedral cells, markedly irregular in shape and separated by a connective tissue stroma which is rich in blood vessels. The cytoplasm is abundant, finely granular and takes a basophilic stain with hematoxylin-eosin. The nuclei vary in size and shape considerably and contain one or more well defined nucleoli. Within the cytoplasm of the cells, as well as between the cells, hyaline inclusion bodies are frequently seen. A characteristic dark brown color is imparted to the tumor when it is immersed in dichromate solution.

Qualitative extraction studies of these tumors have revealed the presence of a pressor substance identical in pharmacologic effect with epinephrine.² Quantitative extraction studies have revealed amounts of adrenalin varying from 67 to 1200.0 mg. per tumor.

The attacks which characterize the disease may occur spontaneously, or as the result of any stimulus which causes a discharge of adrenalin into the general circulation (pressor response). Such stimuli may consist of emotional excitation, change in body position, manual manipulation of the tumor, massage of the abdomen on the tumor side, immersion of the extremities in cold water, starvation, or the administration of adrenalin, insulin or histamine. Minor operative procedure has been known to produce an attack.

The classical *clinical picture* of pheochromocytoma is attended by marked vasoconstrictive phenomena which may consist of (1) periodic episodes of paroxysmal hypertension (rising to heights which frequently attain 250 mm. of mercury systolic pressure and occasionally reaching 300 mm. systolic pressure), (2) cardiac palpitation, pounding headache, vomiting, tremulousness, severe anxiety and weakness, (3) associated vasomotor phenomena such as alternating blanching and flushing of the extremities, (4) diaphoresis, (5) low peripheral skin temperature with elevation of torso temperature, (6) shock, in cases where the attacks persist over a long period of time. This type of shock has been shown to be produced by a reduction in the volume of circulating blood from prolonged vasoconstriction. Experimentally³ this has been shown to occur in animals given large doses of adrenalin intravenously. In half the number of instances hyperglycemia and glycosuria are evident during the episode. The urine is usually decreased in output during attacks and may contain albumin, casts and red blood cells. Between attacks the urine may be normal.

Electrocardiographic studies occasionally show arrhythmias.

The duration of the attack may vary from minutes to many hours. In one case⁴ the attack lasted for thirty six hours. Death may occur during an attack as a result of shock, left heart failure, coronary thrombosis or cerebral accident.

If the paroxysmal hypertensive episodes continue over a long period of time, the hypertension may become fixed. In an analysis of eighteen

cases⁵ by Howard and Barker six developed permanent hypertension. Such permanency is almost always associated with optic fundal and renal changes observed in any group with severe and prolonged hypertension.

The *diagnosis* of this disease is dependent upon (1) the typical symptom complex and clinical findings, (2) evidence of pressor response tests, (3) the finding of pressor substance in the blood at the height of the attack, (4) the roentgenographic demonstration of a tumor mass in the adrenal areas by perirenal insufflation⁶ and (5) in the case of large tumors depression of the kidney by the mass as noted by pyelography. In the presence of a tiny adrenal tumor or in the instance of an extra adrenal tumor, roentgenographic techniques may be unrevealing. In such instances the diagnosis may be presumptive on the basis of collateral evidence.

The *treatment* of this disease is surgical. Therefore, any suspicion that a case may be pheochromocytoma calls for exploratory operation with removal of the tumor. Furthermore, it should be emphasized that, in view of the hazards associated with this disease, operative intervention must be prompt.

The operative mortality has been low with suitable special preoperative and postoperative care discussed in the presentation of our cases and the therapeutic response to a successful and complete procedure has been dramatic.

In those cases of course in which the tumors are bilateral or malignant or in which the tumor mass has not been completely extirpated⁷ we may expect a return of symptoms. This occurred in one of the previously reported cases in which the tumor was incompletely removed. In another case (Case II in this article) in which the tumor proved multiple and malignant with invasion of the smaller radicles of the renal vein we must anticipate a recurrence of symptoms.

REPORT OF TWO CASES

The following two heretofore unrecorded cases will illustrate many of the points dealt with in the preceding discussion. They are also presented because Case I represents perhaps the largest pheochromocytoma ever removed surgically and because in Case II we were dealing with a multiple malignant type.

Case I Pheochromocytoma of the Adrenal with Marked Cystic Degeneration

The patient (W. D.) was a 36 year old man whose history of the present illness dated back approximately fifteen years. During this period of time he had had recurrent episodes characterized by the sudden onset of nausea and vomiting, marked cardiac pounding, pallor and sweating of the face and alternating pallor and cyanosis of the extremities. These attacks would last from five minutes to a half hour and subside spontaneously. Originally the episodes occurred infre-

quently averaging once a week or less. With the passage of time both the intensity and frequency of the attacks increased and for a period of five years prior to the operation such episodes occurred one to four times daily with only an occasional free interval of several days. The patient recalled that on several occasions the blood pressure was noted to be elevated during the attack. There were no clear cut factors which precipitated the episodes. They occurred during moments of exertion as well as at complete rest. They seemed to bear no particular relationship to food.

For ten years the patient was aware of the existence of a mass in the right upper abdominal quadrant. This mass gradually increased in size but was pain



Fig 201—Retrograde pyelogram showing marked downward displacement of the kidney by a suprarenal mass

less and nontender. The patient had observed that vigorous palpation of the mass would occasionally induce a characteristic attack. There were no other significant findings in the patient's history other than a loss of 15 pounds in weight during the past two years.

On physical examination the optic fundi were essentially normal. The heart was not enlarged. The sounds were perfectly regular and a soft systolic murmur was audible over the base in the pulmonic area. The apical rate was 100 per minute and neither of the basal sounds was unduly accentuated. In the right upper quadrant of the abdomen a huge dome shaped mass was palpable. The mass was firm nontender and extended well below the umbilicus and to the midline medially. With the patient at rest in the prone position the blood pressure varied between

120/80 and 130/110 mm. of mercury. Massage of the mass for three minutes usually initiated a characteristic attack, and the blood pressure would rise to a level between 190/120 and 204/134 mm. of mercury.

The basal metabolic rate was plus 24 per cent on one occasion and plus 15 per cent on another. Repeated electrocardiographic tracings showed a left axis deviation but no evidence of myocardial damage. Repeated urinalysis both during attacks and in free intervals, showed no glycosuria. The specific gravity varied from 1.020 to 1.028. A trace of albumin was always present, and on one occa-



Fig. 20¹ (Case I) - Plain film of the abdomen showing a curvilinear line of calcification in the tumor mass

sion the protein in the urine was considerably increased. Microscopic examination of the urinary sediment revealed the constant presence of occasional red blood cells and 4 to 10 white blood cells per high power field. The sedimentation rate was normal. The total proteins of the serum were 6.3 gm. per 100 cc., of which the albumin fraction was 4.6 gm. and the globulin fraction 1.7 gm. per 100 cc.

The blood hemoglobin was 94 per cent, the red blood cell count 5.14 million per cu mm., the white blood cell count was 22,000 per cu mm. The differential study revealed the presence of 78 per cent polymorphonuclear leukocytes, of which 4 per cent were nonsegmented, 18 per cent lymphocytes, 3 per cent monocytes, and 1 per cent eosinophils. The platelet count was 210,000 per cu mm.

Intravenous pyelography showed the presence of a huge mass in the right upper abdominal quadrant. The kidney was markedly depressed by this mass, distortion and compression of the calices. Studies of the gastrointestinal tract were entirely normal. There was a slight displacement of the second portion of the duodenum to the left. A curvilinear line of decalcification was evident in the tumor mass (Fig. 202).

Because of the typical symptomatology, it was strongly suspected that we were dealing with a case of pheochromocytoma of the adrenal gland. Accordingly, the patient was prepared for operation.

Preoperative Preparation of the Patient—On the morning of the operation a constant intravenous drip of isotonic saline was started which was continued throughout the operative procedure and for a period of several days thereafter. Just prior to operation the patient received 10 cc of whole adrenal cortical extract (Upjohn) intravenously. Treatment with whole cortical extract in the dosage of 5 cc subcutaneously was continued every six hours until the patient was well out of shock. During the operative procedure we attempted to control the inordinate elevation of blood pressure with amyl nitrite. The precipitate drop in blood pressure was treated with transfusions of whole blood and frequent administrations of 2 to 3 minims of neosynephrin and 0.5 cc of epinephrine every fifteen minutes until the systolic pressure reached 90 to 100 mm of mercury. After the operation this therapy was continued every hour until the patient recovered from shock.

Operation—An incision was made, starting at the right costovertebral angle and extending anteriorly along the course of the twelfth rib. As the operation progressed and because of the subsequent findings, it was necessary to extend this incision both posteriorly towards the vertebral column as well as anteriorly across the midline of the abdomen towards the left upper quadrant of the abdominal wall. Thus the incision represented more than a hemisection of the body. To facilitate further exposure, practically the entire twelfth rib was removed.

The incision as outlined exposed, both extraperitoneally as well as transperitoneally, a cystic tumor so tremendous in size that it extended in all directions, pushing the liver and diaphragm high up into the chest cavity to reach a point about level with the fourth rib anteriorly, extending downward mesially and posteriorly to occupy most of the abdominal cavity on the right side as well as a large portion of the cavity on the left. Numerous markedly distended veins were seen coursing over the surface of the tumor. At some points where the tumor came into contact with the colon, these veins were continuous with markedly distended veins in the mesocolon. The right kidney was pushed downward towards the crest of the ilium by the above mentioned mass.

At the outset it seemed that removal of this gigantic mass would

be an impossible surgical feat. It was decided, however, in view of the ultimate fatal outcome if nothing were done, to make every effort to extirpate the tumor. By ligating the numerous blood vessels attaching themselves to the mass as well as by dissecting the mass from its various fibrous attachments mobilization was finally accomplished. At the main pedicle of this tumor the vein was at least $\frac{3}{4}$ inch in diameter with a wall thickness of about $\frac{1}{4}$ inch. The pedicle vessels were doubly ligated with linen thread; chromic catgut was employed for the smaller vessels. The mass thus was removed in toto with its cap



Ft

17—Gross section of removed tumor

sule intact. A large retroperitoneal dead space remained after the removal of the tumor. The peritoneal portion of the incision was closed by a continuous suture of chromic catgut. Drainage of the large retroperitoneal dead space was effected by the use of gauze, rubber dam and rubber tube all placed retroperitoneally. The abdominal wall was then closed in layers employing chromic catgut for the muscles and fascia, and pincettes were employed for the closure of the skin.

PATHOLOGY—The specimen after removal was much smaller in size because a great deal of blood was emptied from its interior during its extirpation. Pathological

laboratory description "Specimen is a cystic tumor the size of a large honeydew melon and weighing 2000 gm (Fig 203) The tumor shows a thick fibrous capsule to which some fascial tissue is adherent and in one area yellowish tissue is seen which resembles adrenal cortex Scattered over the surface there are a few pin point yellow nodules, which in color resemble adrenal cortex The tumor is cystic, and on opening it, a large amount (about 1000 cc) of fluid escaped One of the cavities within the tumor is relatively smooth walled but some elevated types of plaques of soft brownish gray tissue were found The other cavities are filled with friable grayish necrotic tissue The outer rim of the mass is formed by brownish relatively cellular tumor tissue within which areas of necrosis can be found *Microscopic diagnosis* Pheochromocytoma of the adrenal, with marked cystic degeneration" (Fig 204)

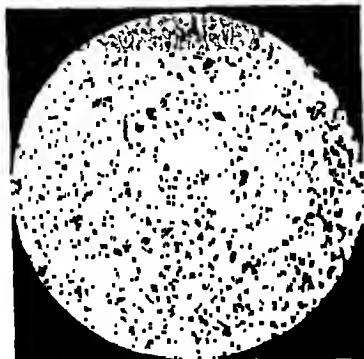


Fig 204 (Case I) —Microscopic section of removed tumor

Comment should be made as to the clinical course during the operative procedure At one point during the manipulation of the mass the blood pressure rose above the extreme height of the sphygmomanometer At this point the pulse was imperceptible The extremities were cool but the torso was warm so that we were not dealing with shock in the true sense of the term We were confronted, however, with a picture caused by the discharge of tremendous amounts of adrenalin into the general circulation Directly subsequent to the removal of the tumor, on the other hand, the blood pressure dropped precipitously to levels at about 50 mm of mercury systolic pressure, and a diastolic pressure of 20 mm of mercury With suitable therapy, hereinafter outlined, the blood pressure rose to within normal limits in about forty-eight hours

Postoperative Course—After the abatement of shock, the major problem was that of dealing with infection in the large retroperitoneal dead space which gradually diminished in size. The patient progressed satisfactorily and was discharged from the hospital on the thirty-ninth postoperative day.

Two months after discharge from the hospital the patient was perfectly well. There had been no attacks since the removal of the tumor. He had gained 12 pounds in weight, blood pressure varied from 100/60 to 120/80 mm. of mercury. Tests of the urine were completely negative and massage of the abdomen failed to induce any discomfort.

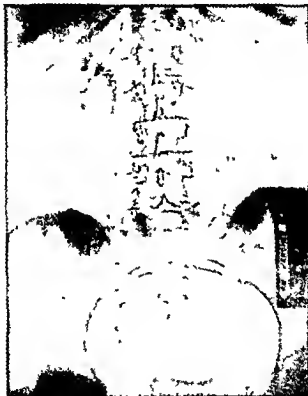


Fig. 205 (Case II)—Excretion pyelogram showing downward displacement of the left kidney by suprarenal mass. Calyces are distorted and faintly outlined. The pyelogram of the right kidney is normal.

Case II. Pheochromocytoma of the Adrenal, Multiple Malignant Type

The second patient (E. R.) was a married woman of 58 who had "spells of nervousness" of ten years' duration. These attacks were characterized by the sudden onset of marked cardiac palpitation, pallor of the face, paraesthesias and marked pallor of the extremities. A severe, throbbing headache involving the entire head was occasionally present. Each attack was associated with a sense of great anxiety and marked urinary frequency. These episodes appeared several times daily, would last for approximately five minutes, and would subside spon-

taneously. They apparently bore no relationship to exertion or emotional upsets. However, the patient had observed that lying on the right side would frequently initiate the attack.

On physical examination, the patient was found to be a well nourished middle aged woman. The optic fundi were quite normal. The heart was not enlarged, and the sounds were regular in rate and rhythm and not unduly accentuated. The resting blood pressure was found to vary between 140/80 and 160/70 mm of mercury. A characteristic attack was then induced by having the patient lie on the right side for five minutes. During the height of this attack the blood pressure rose to 300/160. On several subsequent occasions during attacks the blood pressure was found to vary between 235/110 and 270/160 mm of mercury.

The remainder of the physical examination was essentially negative except for the fact that the lower pole of the left kidney was palpable.

The blood hemoglobin was 83 per cent while the red cell count was 4.05 million per cu mm with a normal differential smear. The urine showed a specific gravity of 1.020 with a trace of albumin but no sugar, either during attacks or during free intervals. The microscopic examination of the urinary sediment revealed the presence of an occasional hyaline cast and a few white blood cells.

An intravenous pyelogram showed a depression of the left kidney with some distortion of the calices suggesting the presence of a tumor mass above this kidney (Fig 20y). The electrocardiographic tracing was not particularly abnormal. The P-R interval varied between 0.1 and 0.2 second. P_2 and P_3 were high and peaked.

Supportive Care—On the morning of the operation, a continuous intravenous drip of isotonic saline in 5 per cent glucose was started. This was continued throughout the operation and for the next twenty four hours until the patient was well out of shock. In addition, she received 10 cc of whole adrenal cortical extract intravenously and 10 mg of Percorten intramuscularly preoperatively. During the operative procedure, she was given a whole blood transfusion of 500 cc and in addition 10 cc of whole adrenal cortical extract intravenously. Directly after the removal of the tumor masses the blood pressure fell to 90/50 but it promptly attained normal levels following the intravenous administration of 0.5 cc of 1:1000 epinephrin hydrochloride and 3 mm of neosynephrin. Postoperatively, 5 cc of whole adrenal cortical extract was administered subcutaneously every six hours for the next forty eight hours. At no time after the operation did the blood pressure level fall below 100/60 mm of mercury.

Operation—Through a left loin muscle-splitting incision with excision of the twelfth rib, the retroperitoneal space was exposed and found to contain a huge tumor mass lying in the subdiaphragmatic area and apparently involving the adrenal gland. By its tremendous size it had caused a descent of the left kidney towards the iliac fossa. The entire mass was mobilized by dividing numerous adhesions as well as multiple large varicose vessels which were coursing over the surface of the tumor. The blood supply to the mass seemed to arise from a combination of the adrenal, diaphragmatic, and branches from the left renal vessels. All these vessels were ligated and divided. The main venous vessel was huge in caliber and measured at least $\frac{5}{8}$ inch in

diameter. After the removal of the main mass a small amount of tissue was noted close to the renal pedicle which represented residual tumor. This was excised. Another separate tumor measuring about $1\frac{1}{2}$ inches in diameter was seen lying mesial to the site of the main tumor, which measured about $7\frac{1}{2}$ inches in diameter (see pathology report for description of tumor). Following the removal of the second smaller tumor, numerous tiny branches of vessels were ligated in the depths. There was a moderate amount of oozing coming from the subdiaphragmatic space. This was easily controlled by ligature and packing. The retroperitoneal space was drained by the use of iodoform gauze packings as well as rubber dam drains. The abdominal wall was closed in layers using figure of 8 chromic catgut sutures for the muscle and fascia. Silk sutures were employed for the skin.



Fig. 206 (Case II) — Two tumors in gross section.

PATHOLOGY "Specimen consists of two more or less round masses of tumor tissue apparently well demarcated (Fig. 206). The smaller weighs about 25 gm and is about 4 cm in diameter. It has a somewhat cystic feel with a bluish color shining through the surface which reveals distended vessel channels and adherent fat tissue more prominent in the area of resection. There is a large ligated artery present which has a circumference of more than 2 cm. On opening the artery a small dimple is found apparently a branch in the region of the tumor, which however cannot be probed. Section of the tumor reveals a rather even appearance. The mass is solid gray with a generally reddish purple overtone with some slightly grayish areas visible. No adrenal tissue is recognized grossly on this smaller mass. The consistency is moderately firm. The larger mass weighs 530 gm, is slightly oval, and measures about 13 cm in its largest diameter. There is adherent fat tissue present on the surface and a small denuded area apparently the site of attachment about 3 cm across. In addition there is a small amount of orange tissue which has the appearance of adrenal cortex. This is mostly in a somewhat linear area

about 4 cm. across, but there are tiny tabs elsewhere. The tumor has a mottled purple red color and an uneven consistency. This mass on section has a rim and multiple septa of firm hemorrhagic tissue, similar in appearance to the smaller mass. The major portion, however, is occupied by cystic areas which are composed of 1 mm. of gray tissue which forms the lining. Centrally the tissue is broken down. There is tan-colored slough and slightly thick tan fluid. In areas, slightly hemorrhagic fluid exudes from these broken-down areas. *Microscopic diagnosis:* 1. Pheochromocytoma of the adrenal. The surface of the main tumor shows flattened adrenal tissue in places (Fig. 207). 2. A second smaller tumor should

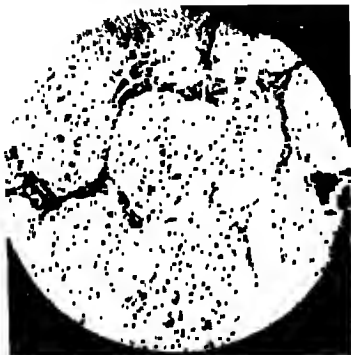


Fig. 207 (Case II) —Microscopic section of removed tumor

be interpreted as metastatic. 3. Fragments of tissue received separately contain veins partially infiltrated by tumor. No adrenal tissue found in these fragments.

Postoperative Course.—The patient received a transfusion, penicillin prophylactically, adrenalin, whole adrenal cortical extract and neosynphrin, as needed. Pneumothorax which developed was treated conservatively. The drains were removed one by one, the last one on the twenty-second postoperative day. The postoperative course was relatively smooth except for a febrile rise on the tenth to the twelfth postoperative day, up to 103.2° F. This was probably due to pulmonary infection in the collapsed lung. Temperature was thereafter normal and the patient was discharged on the twenty-fourth postoperative day.

COMMENT

Both these cases are unusual in several respects. In the instance of the first patient, the symptoms lasted over a period of fifteen years,

during ten of which an abdominal mass was readily evident. The tumor mass was extraordinarily large and weighed 2000 gm. It is of interest that despite the long duration of the disease and the enormous size of the tumor the patient failed to develop a permanent hypertension and eventually recovered completely. The second patient, too, presented symptoms over a prolonged period of time. The presence of two distinct pheochromocytomas arising from the same pedicle is most unusual. The failure to recognize the presence of the smaller tumor might have nullified the results of the operation. The malignant nature of the tumor makes the prognosis in this case dubious.

It is unfortunate that in both instances so many years elapsed before the true nature of the disease was recognized. A careful history elicited the usual characteristic symptoms. Unless the possibility of a pheochromocytoma is borne in mind, the overall picture may be superficially confused with that of an anxiety neurosis. However, if the physician is adequately alert to the possibility of an adrenal medullary tumor, further investigation can readily establish the diagnosis. Thus, episodes of paroxysmal hypertension with or without a concomitant glycosuria, the presence of a palpable abdominal mass, or the demonstration of such a mass by intravenous or retrograde pyelography or by perirenal insufflation must arouse the strong suspicion of the existence of a pheochromocytoma. Occasionally, the hypertension may be of a permanent character rather than paroxysmal. Also, the tumor might be extramedullary in location and hence perhaps not demonstrable by the usual radiographic techniques. In such instances, a careful history may create enough suspicion to warrant a surgical exploratory procedure.

Once the diagnosis is suspected or actually established, the treatment of this disease involves the surgical removal of the tumor. The patient must be prepared for operation by the generous use of adrenal cortical extract and intravenous fluids. The removal of the tumor is usually followed by shock which may be profound and of long duration. During this period, the frequent use of epinephrine and neosynephrin, adrenal cortical extract as well as blood or plasma transfusions and a continuous intravenous drip of isotonic saline and 5 per cent glucose must be continued until the patient is well out of danger.

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INTESTINAL OBSTRUCTION

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REVIEW of the literature of the past few years reveals many instructive reports on intestinal obstruction. It seems unnecessary at this time to repeat what has already been called to the attention of the profession. The object of this paper is to emphasize a few of the important points which I have found useful in the diagnosis and treatment of acute intestinal obstruction. The causes for intestinal obstruction have been well classified by Wangensteen and others. In this brief discussion, I shall consider only obstruction of the large bowel due to tumors, and early and late postoperative obstruction of the small bowel.

DIAGNOSIS

The diagnosis of *large bowel obstruction due to tumors*, in a previously unoperated patient, is as a rule not difficult. There is usually a history of intermittent, cramplike pain which frequently follows the ingestion of some indigestible food such as shellfish, mushrooms or corn on the cob. Such a history in the absence of elevation of temperature and pulse rate suggests intestinal obstruction. Not infrequently the patient and doctor attribute these symptoms to the indigestible foods, and valuable time is thereby lost arriving at an early diagnosis.

The obstructed patient not infrequently will pass several loose stools following the first few episodes of pain. This may be misleading unless one realizes that the gut, distal to the obstruction, is emptied by strong peristaltic waves set up by the bowel in an effort to overcome the obstruction. Vomiting in obstruction of the large bowel is usually a late symptom and does not occur if the ileocecal valve is competent. The temperature and pulse rate are not affected until the condition becomes advanced.

The onset of *late postoperative obstruction of the small intestine* which is usually due to adhesive bands, is similar to the symptoms mentioned above except that vomiting may occur earlier, particularly in lesions that are high in the small intestine. Once vomiting occurs, it is usually repeated and copious, and the vomitus which first consists of gastric contents soon becomes feculent (not fecal) in character. Early postoperative obstruction of the small intestine is usually due to inflammatory adhesions. A not uncommon error in obtaining

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the history of an obstructed patient can best be illustrated by an experience which I had not long ago. I was called to see a boy in the hospital of a neighboring city, who was suffering from advanced, recent postoperative obstruction. When asked if he had passed gas, he replied "yes." When asked which way he passed gas, he replied "by mouth." The attending physician and a previous consulting surgeon had assumed that the gas was being passed by rectum, and were misled into believing that the patient could not be obstructed.

The value of *colonic irrigations* as a diagnostic and therapeutic procedure in intestinal obstruction has not been stressed sufficiently. The procedure usually is relegated to a nurse or an orderly. The significance of the return frequently is misinterpreted. I have watched these irrigations being given and I have heard the irrigator state that gas and fecal matter returned, when it was obvious that the amount of gas returned was not more than had been permitted to run in with the solution, and the fecal matter, only small flakes of feces washed from the walls of the colon. I do not recall ever having a resident admit that he had had any training in colonic irrigation, either in medical school or during his internship. I consider this training important enough to instruct all of my residents in the technic and interpretation of colonic irrigation in intestinal obstruction. In addition, the residents of the New York Post Graduate Hospital perform the irrigations in obstructed patients. The early returns obtained from an irrigation are of little diagnostic value, as the feces obtained are those which are left in the bowel distal to the point of obstruction. Once the return becomes clear, and gas is no longer expelled, if the irrigation is continued and the patient obtains no relief from cramps and distention, the diagnosis of obstruction is strongly suggested. In the obstructed bowel, the amount of fluid that can be run into the colon becomes less as the irrigation progresses, for the bowel distal to the obstruction collapses as it is cleansed, and its capacity is therefore reduced. In paralytic obstruction the return will continue to be colored.

Digital examination of the rectum gives valuable information in differentiating between paralytic and mechanical obstruction. I have found that the bowel that is mechanically obstructed is collapsed against the examining finger. The paralytic bowel will present a dilated ampulla of the rectum. This test is best done following the irrigation.

In the limited space available for this discussion, I shall omit the theoretical considerations regarding absorption of toxic materials from obstructed loops, and the various chemical aberrations that occur in intestinal obstruction.

In the vast majority of patients suffering from a malignant obstruction of the large bowel, the lesion is found in the left colon in the region of the sigmoid. Obstruction is not a prominent symptom in

carcinoma of the right and transverse colons. However, it is usually an early symptom in carcinoma of the left colon. The cause is obvious. The right colon is of large caliber and its contents are liquid. The left colon is of much smaller caliber and its contents are solid.

TREATMENT

Large Bowel Obstruction—The treatment of obstruction of the large intestine is surgical. It must be emphasized, however, that before proceeding with surgery a period of preoperative preparation is essential. Intubation of the small intestine in the presence of a competent ileocecal valve is a useless procedure. The stomach should be emptied with a Levin tube, and measures to combat dehydration should be put into operation. The mortality rate can be reduced by good preoperative treatment. At times it is difficult to convince the family physician and relatives that valuable time is not thus wasted. In an average case, only a few hours are needed to correct the dehydration.

When a patient is admitted with suspicious symptoms of obstruction of the large bowel, if the condition permits, a barium colon enema is given. This usually confirms the diagnosis. It should be emphasized that a barium meal should never be given by mouth if there is a possibility of obstruction. At times the barium colon enema may be misleading. The head of the barium meal may stop abruptly, indicating that the obstruction is complete, whereas small amounts of gas and fecal matter may be able to pass the obstruction. In partially obstructed cases, if a rectal irrigation is given by a trained individual, the obstruction frequently can be overcome and the patient can then be prepared for resection. Irrigations with hypertonic saline solution are given daily, and when gas and fecal material are passing the point of obstruction, a daily saline cathartic is administered. One must be cautious with the use of strong saline catharsis because of the danger of perforation. I have a patient in the hospital at the present time in whom this occurred. This patient did not present symptoms of obstruction when preoperative treatment was begun. His x rays showed a malignant lesion in the sigmoid, and the patient appeared to be in excellent condition. He was given a dose of licorice powder on admission, and three hours later, in error he was given a dose of Pluto water. Four hours afterward the patient was seized with severe abdominal pain and went into collapse. Examination revealed a rigid abdomen and elevation of temperature and pulse rate. The patient was operated upon and the abdomen was found to contain a fair amount of free fluid which was emerging from a perforation at the site of the carcinoma. The perforation could not be repaired. The tumor was resected. The distal end of the colon was clamped and the proximal end was brought out. The wound was closed around the bowel with drainage. A Paul's tube was inserted into the proximal end of the

colon and left open. The patient made an uneventful recovery and an end-to-end anastomosis was established two weeks later.

I have used this procedure many times in obstructed carcinoma of the left colon. It has the advantage of removing the growth and overcoming obstruction at the first operation. It should not be attempted if the seat of the growth is in an inaccessible part of the bowel, such as the splenic flexure. After ten to fourteen days, when the patient's condition has improved, an intraperitoneal end-to-end anastomosis is performed. If the anastomosis is done within this time there is little danger of peritonitis, whereas if it is delayed for several weeks the danger is increased. This, in all probability, is due to the fact that there is a certain period of time following the first operation during which the patient is immune to infection. No attempt is made to suture the walls of the bowel as is done in the first stage Mikulicz operation, which operation necessitates the removal of the spur.

If the patient's condition is too serious to justify this procedure, or if the site of obstruction is in an inaccessible location, it is preferable to do an appendicostomy, using a No. 22 or 24 rectal tube, rather than a catheter. If the appendix has been taken out a transverse colostomy or cecostomy may be performed.

I have found appendicostomy to be a most satisfactory way of relieving obstruction. If it is properly performed, there is no danger of leakage when the tube is removed. A McBurney incision is made and the appendix located and delivered. It is divided with a cautery, $\frac{1}{4}$ inch distal to the cecum, between two straight clamps. A purse string suture is inserted around the base of the appendix and the loop and two ends of the suture are held by an assistant. The wound and intestine are carefully protected by saline pads to avoid contamination, as there is usually some leakage from the distended cecum. This leakage is prevented to a great degree if the purse string suture is properly held. The proximal clamp is then removed and, as the end of the stump is opened, the tube is inserted into the cecum for a distance of 4 to 6 inches. The extreme end of the stump is sutured to the wall of the tube on each side with a catgut suture. The stump is then inverted by pressure on the tube, thereby having the serous coats in apposition when the tube is removed. If a piece of omentum can be found it is advisable to make an opening through which the tube may be inserted before entering the stump of the appendix. The omentum is sutured around the tube after it has been inserted. When the abdominal wound has been closed, the tube is anchored to the skin by a deep silk suture.

If there is enormous distention of the cecum, a gallbladder trocar and cannula is inserted into the cecum by forcing it through the opened end of the stump of the appendix, which can easily be done if the purse string suture is held properly. The trocar is partially withdrawn and gas and feces are allowed to escape through the cannula.

Tension on the wall of the cecum is released so that the operation may be completed without soiling

When an appendicostomy is performed for an obstructing lesion of the right colon several days before proceeding with the resection of the right colon a Miller Abbott tube is passed into the small intestine and the appendicostomy tube is removed just prior to operation. A one stage resection and anastomosis is performed and the Miller Abbott tube is left in place for four or five days to decompress the anastomosis or until gas and feces have passed by rectum

Small Bowel Obstruction—In small bowel obstruction the preoperative preparation is more difficult and time consuming. The patient's condition is usually more serious, the dehydration and chemical depletion more severe. Distention in small bowel obstruction is more marked and must be corrected prior to operation. Decompression is accomplished either with a Levin tube or a Miller Abbott tube. One should not be misled by the apparent improvement frequently seen after the stomach has been emptied and after 1000 to 2000 cc of saline in glucose have been administered. The relief afforded is frequently dramatic and the patient may feel so much better that the advisability of an operation may be questioned. I have recently operated upon a woman 65 years of age who was admitted to the Post Graduate Hospital with a history of small bowel obstruction due to a band from an appendix operation performed twenty five years before. After several quarts of foul yellow material had been obtained by lavage and 1500 cc of saline and glucose had been given the abdominal distention and cramps disappeared. She felt so much better that I had great difficulty in convincing her and her family that operation was necessary. When the abdomen was opened a loop of ileum 12 inches long was found herniated through a small string like band. Fortunately after releasing the constriction the color returned, and it did not require resection.

Late Postoperative Obstruction—When a patient is suffering from small bowel obstruction with a history of an operation some months or years previously the chances are that it is due to a band. With a history of this kind many think the Miller Abbott tube is indicated and lose valuable time in trying to pass it. The Levin tube which is easily passed accomplishes as much as the Miller Abbott because a tube of larger caliber can be used. The danger to the patient who has a history of a former operation and is suffering from small bowel obstruction is gangrene of the loop of the bowel which has passed through a constricting band. The Miller Abbott tube can only pass to the point of obstruction and cannot relieve the bowel which is caught. Thus the use of the Miller Abbott tube cannot be advocated as it frequently gives complete relief to the patient for several days, and no symptoms are present until the loop actually becomes gangrenous. This delay endangers the patient's life. The Miller Abbott

tube should be used only as a preoperative measure in early small gut obstruction. Patients with late small bowel postoperative obstruction should be operated upon as soon as dehydration and distention have been overcome. Wangenstein has stated that "the possibility of failure to achieve satisfactory decompression with conservative means (suction) prompted McKittrick and Sarris (1940) to suggest that all patients coming to hospital with obstruction within twenty-four hours of onset of symptoms, should be subjected to immediate operation." Unfortunately, few patients suffering from obstruction are admitted within the first twenty-four hours.

If gangrene of the loop of the intestine already has occurred, it is a great mistake to attempt primary anastomosis after resection. The two ends of intestine should be left open on the abdominal wall until the patient's condition justifies anastomosis. To prevent leakage on the abdominal wall with consequent irritation, a Pauls tube is tied into the proximal end as is done in the operation on the colon. When the Pauls tube is removed, the skin of the abdominal wall is protected by frequent applications of Enzo-cal ointment*. Formerly, we used aluminum powder or paste, but have found Enzo-cal much more satisfactory as it is cleaner, not greasy, and has a pleasant odor.

Early Postoperative Obstruction—In early postoperative obstruction, the diagnosis may be more difficult. The early symptoms of cramplike pain may be mistaken for gas pains which occur in the first few days following an operation. Another frequently misleading symptom may be diarrhea, which may be due to the hyperperistalsis set up in the small intestine in an effort to overcome a partially obstructed loop of small intestine that has become adherent or kinked. As the obstruction becomes more complete, the usual symptoms are more clearly defined. It is during this early stage that the Miller-Abbott tube (contraindicated as a curative measure in late obstruction) has its greatest benefit. Whereas most of these obstructions may be relieved by intubation and suction if the patient does not show signs of improvement, as is evidenced by persistent distention and increase in pulse rate, too much time should not be wasted in relying upon the tube. While it is true that suction if properly used, will relieve many patients, it is not infallible. It requires a great deal of courage to continue its use when we know that a simple enterostomy, performed when the patient is in good condition, affords relief.

Many surgeons hesitate to operate upon patients who have recent postoperative obstruction. The obstruction is always caused by inflammatory, fibrinous adhesions or kinking of the intestine in the lower abdomen or pelvis. An exploration is not necessary. A short rectus incision is made on the side opposite the original operation. The first piece of dilated bowel that presents itself is selected for the site of enterostomy. No attempt should be made to introduce the hand into

* Prepared by Crooks Chemical Company.

the abdomen to determine the cause of obstruction or to relieve it. A piece of the greater omentum should be picked up with a sponge forceps. A No. 22 or 24 rectal tube is inserted through an opening in the omentum. A purse-string suture is placed in the intestine and the assistant holds it after the wound has been well protected, and enterostomy is completed. The omentum is sutured around the enterostomy. It does not matter whether the tube is placed proximally or distally. The intestine is replaced and the wound is closed. The edge of the tube should be sutured to the skin with a double silk suture which should be tied loosely. Abdominal dressing is applied. I have found that irrigation of the intestine through the tube with hypertonic salt solution tends to lessen toxic absorption which occurs after distention is lessened. In three or four days, obstruction is relieved and the patient begins to have normal bowel movements which are frequently diarrhea like. At this time suction may be discontinued. The tube may then be clamped to prevent loss of fluids but reopened, should cramps or distention recur. The tube should not be removed for ten or twelve days. When removed, leakage from the intestine is extremely rare.

Anesthesia—In my experience spinal anesthesia has been by far the most satisfactory and safest anesthetic for operations in intestinal obstruction either of the large or small intestine. Graham and Brown have stated that the surgeon who operates upon a patient suffering with acute intestinal obstruction using inhalation anesthesia if adequate facilities for spinal anesthesia are available, is guilty of malpractice. In operations upon patients who are suffering from advanced intestinal obstruction, no matter how effective suction by means of a Levin tube has been there is frequently regurgitation of intestinal contents into the stomach, which may be vomited, and inspired if general anesthesia is used. There is much less danger of contamination in opening the bowel when complete relaxation is obtained through the use of spinal anesthesia.

SUMMARY

1 The mortality in intestinal obstruction is dependent upon early diagnosis, adequate preoperative preparation and prompt surgery where indicated.

2 Colonic irrigation is of inestimable value in the early diagnosis of obstruction, provided it is given skillfully and interpreted properly.

3 A valuable sign in the differential diagnosis of mechanical and paralytic obstruction is presented in simple rectal, digital examination. Paralytic gut presents a dilated ampulla. The mechanically obstructed gut is collapsed about the palpating finger.

4 The Miller Abbott tube is a valuable instrument in the treatment of early postoperative obstruction. It may be a dangerous instrument in the treatment of late postoperative obstruction and it is

a useless instrument in colonic obstruction, for it cannot decompress the large intestine in the presence of a competent ileocecal valve

5 One-stage operation for obstruction should not be undertaken in the presence of distended or dilated intestine

6 Enterostomy is a safe and effective procedure for the treatment of small intestinal obstruction when done early

7 Spinal anesthesia is the anesthetic of choice

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DIVERTICULITIS OF THE COLON

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DIVERTICULITIS of the colon is for the most part treated by the physician. A small number of patients suffering from this disease require surgical intervention. In general it may be stated that the indications for surgery are the complications.

There is no unanimity of the opinion as to the causative factor or factors that produce diverticuli. Many obese persons after the age of forty develop sacculations along the colonic wall. No confusion exists as to the mechanism initiating the inflammatory process, for it is agreed that blockage at the neck of the sac will result in such a reaction.

Some believe that acquired diverticula usually develop on the mesenteric side through openings between branches of the terminal blood vessels. Frequently they are found in the antimesenteric border or even protruding from the lateral wall. Increased intracolonic pressure atrophying weakened musculature with advancing age, localized changes in the resisting power of the wall with the resulting muscular deficiency—all have their advocates.

Where a diverticulum has not reached the surface of the colonic wall but lies buried in its layers, edema and swelling supervene and an abscess may form which at times perforates into the coats of the colonic wall. To this process Eggers¹ has given the term 'acute sigmoiditis.'

During the past eleven and one half years from January 1, 1934, to July 1, 1945 certain informative data have been obtained from a study of 131 patients suffering from diverticulitis of the colon and treated on the various services at The Roosevelt Hospital. There were thirty-nine patients operated upon with six deaths, a mortality rate of 15.3 per cent. Of these surgical patients there were nineteen males and twenty females, with an average age of 51 years.

SYMPTOMS AND SIGNS

The majority of the individuals are thick set, obese, with protruding abdomens. In the earlier stages of the disease the patient complains of a lameness and soreness in the lower abdomen usually on the left side. Of our thirty-nine patients who were operated upon

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thirteen demonstrated tenderness and muscular spasm in the left lower quadrant and five in the right lower quadrant. At this stage there is no rise in fever and the leukocyte count is of little help. A thickened, spastic sigmoid can be felt in thin individuals and x-ray examination reveals a characteristic "picket fence" appearance due to serrations of the sigmoid which result from edema and spasm of the circular fibers. Medical measures if immediately instituted frequently avert further progress of the disease.

ROENTGENOGRAMS

Patients reporting to the roentgenologist for x-rays of their colons by means of the barium enema complain most frequently of lower abdominal distress and some pain either general or local. Frequently they give a history of blood in their stools. The roentgenologists tell us that it is difficult to determine the source of the blood from the x-ray findings, but in bleeding patients over the age of 40 diverticula are frequently found. The majority of patients upon the discovery of blood in the stools believe they are suffering from cancer of the colon. In cancer, however, blood is more frequently absent than present.

The filling defect in diverticulitis is usually long. X-rays will frequently reveal an inflammatory lesion with or without visible diverticula or an acute diverticulitis in which diverticula are present with or without tumor formations. The x-rays of course also show inflamed diverticula with obstruction and finally diverticulitis with obstruction.

MEDICAL TREATMENT

The medical or conservative treatment has in the past consisted principally of complete rest in bed, generous parenteral fluids and liquid diet, heat applied to the abdomen, and retention enemas of warm oil or *glycerin suppositories to keep the lower bowel empty*. *Belladonna*, *hyoscamus* and *papaverine hydrochloride* are used extensively as antispasmodics. Sulfonamides and penicillin will no doubt diminish the mortality. Streptomycin, a potent agent which readily destroys the *Bacillus coli*, perhaps may play a curative role.

Should the prediverticular stage fail to subside the inflammatory process advances. Infiltration, deformity and resulting edema produce symptoms and signs of impending obstruction. Fever increases, elevation of the leukocyte count and sedimentation rate ensues and a tender mass can be palpated in the left lower quadrant. Bladder symptoms are frequently complained of. Rectal examination may reveal a tender mass and at times as a result of the mobility of the sigmoid flexure a mass is felt in the right side which is usually diagnosed as appendicitis with or without abscess formation.

At this stage the openings to the diverticula are closed by edema and if a barium enema is given the barium does not enter, the sacculations protruding from the wall are not visualized. The mass due to diverticulitis is tender whereas in carcinoma, unless there is impending perforation, or obstruction tenderness on palpation is minimum.

SURGICAL TREATMENT

The evolution of the operative treatment has been slow, cautious and conservative and rightly so for most operative maneuvers except simple incision and drainage are hazardous and even incision and drainage have resulted in a prolonged morbidity and high mortality. In the management of inflammatory lesions within the abdomen, we know of no other lesion that requires sounder judgment both medical and surgical to insure success. We have performed fifty six operations on the thirty nine patients treated surgically for diverticulitis.

Resection of the diseased segment followed by end to end or side to side anastomosis is not without danger, and let it be emphasized that not infrequently resections with end to end suture result in fibrotic strictures, for being an inflammatory lesion and not a malignant one the entire diseased segment is sometimes inadequately excised. In our group we did resections with end to end suture in five, and resection with end to side in one.

Exteriorization of a diseased redundant sigmoid loop is justified if there is no history of a recent abscess or of acute perforation with a diffuse peritonitis. We utilized the Mikulicz method only twice in our series.

Partial defunctionalizing of the left colon by cecostomy in the presence of complete obstruction is a life saving measure. In seven instances we performed cecostomy.

Colostomy above the involved area is a safe procedure in cases of slight or no obstruction and has in the past justified its use. It is employed more universally than any other operative measure. On seven occasions we employed it.

To completely defunctionalize the left colon after the method of Devine is eminently satisfactory, especially if the patient's condition is good and there is no marked obstruction. We used the method six times in the series.

We have in two instances employed a side tracking procedure (which no doubt has previously been employed by other surgeons) which limits further advance of the disease and puts at rest the involved descending and sigmoid colon thus affording the patient an opportunity of rehabilitation. The transverse colon is divided just to the left of the hepatic flexure this flexure is mobilized an end to side or rarely and more safely a side to side anastomosis is done between the proximal end of the divided transverse colon and a proven healthy lower sigmoid segment, the distal divided end of the transverse colon

is brought out as a mucous fistula, and cecostomy is performed. Thus the fecal stream is completely diverted from the inflamed bowel.

In two instances I have performed colo-colostomy in this fashion with satisfactory results.

Smithwick² suggests a bold attack upon the lesion itself prior to complications. He resected the colon of twelve patients "because of recurrent attacks of diverticulitis, eight because of chronic diverticulitis with a mass simulating carcinoma, eight because of persistent fistulas, four had acute lesions with an associated abscess in two instances, and one had persistent obstruction due to a fibrostenosing lesion." He concludes that "resection of the involved segment of the bowel appears to offer patients suffering from the more severe and complicated form of diverticulitis the greatest hope of improvement. If the operation is carefully planned, the mortality should be low, serious complications few, and unsatisfactory late results infrequent."

COMPLICATIONS

Abscess with Local Peritonitis—The most frequent complication of diverticulitis requiring surgery is abscess formation with local peritonitis. This condition in the absence of obstruction necessitates incision and drainage alone. Certain of our medical colleagues hold to the view that if undisturbed the abscess will break through into the bowel and thus discharge and eventually cure itself. A risk is added to this waiting policy, for the abscess does not infrequently attach itself to the bladder when breaking through, thus causing an enterovesical fistula. With sulfonamides and penicillin in massive dosage and perhaps the new streptomycin a more conservative attitude may be taken. If after a reasonable time the abscess does not subside, simple incision and drainage is indicated. In fifteen of our thirty-nine patients this was carried out. There infrequently may be encountered a condition requiring more than simple incision and drainage. If an associated obstruction is present, cecostomy is indicated. We would prefer transverse colostomy for most of these patients at this stage of the disease but they are not good risks and as little as possible should be done.

After the abscess cavity has been evacuated by suction a fair-sized opening may be found in the bowel wall. Here a divided colostomy of the simplest sort above the lesion would be indicated, since exteriorization of the perforated loop at this time would be an unnecessary risk.

Perforation—Acute perforation of an inflamed diverticulum occurs, diffuse peritonitis ensues with a rigid abdomen and many patients in this group are operated upon as emergency cases with the diagnosis of acute suppurative appendicitis, acute salpingitis or perforated peptic ulcer.

It is true that many of the smaller perforations are immediately sealed off by the omentum or by loops of small intestines or even by the fatty appendages of the descending or sigmoid colon. Some are sealed off by being fixed to the parietal peritoneum or to the bladder. It is interesting to find what a large number of acute perforations was reported by Roscoe Graham.² In his group of forty-four cases there were eleven or 25 per cent in which perforation had occurred abruptly and which necessitated emergency surgery. In our group there was a preoperative diagnosis made of acute diverticulitis with peritonitis in eighteen instances. Perforation had not occurred in all of these and the patients were not operated upon immediately.

Many of these patients are operated upon through a McBurney incision because of the preoperative diagnosis of acute appendicitis. If the diagnosis is found to be erroneous the intermuscular incision is sutured and a lower left rectus incision is made. We have seen numerous instances in which there had been an attempt to enlarge the McBurney incision with a Weir extension and an effort made to drain a perforated diverticulum on the left side or even attempts at the more difficult procedure of suturing the perforation. It does seem justifiable to close a perforated diverticulum by putting in a free fat graft or a pedicle graft or to close in over the opening the fatty appendages of the sigmoid colon. If this is done it would seem reasonable particularly in the desperately ill individual to do a cecostomy in order to decompress for flatus, thus taking the pressure off the sutured perforation. We have carried out closure of the perforations in four patients.

As a rule the tissues are so edematous that no form of suturing can be done and these patients furthermore are desperately ill. In these instances drainage at or near the site of perforation is a more conservative measure. Even if a rubber tube for drainage is inserted and kept in position for a week or ten days many perforations will close spontaneously, some will not.

Obstruction—Obstruction will occur in a certain number of individuals whether the diverticulitis is in an acute or a chronic phase. We know that coincidentally with the diverticulitis there may exist a carcinoma. We do not believe that diverticulitis is a predisposing factor to malignant change or changes.

If the diverticulitis is in the acute phase with elevation of temperature and in associated or impending peritonitis, cecostomy if done early in the course of the disease is a timely procedure. If the obstructive lesion is of a chronic nature a divided colostomy in the transverse colon (preferably by the method of Devine) will relieve the obstruction and defunctionalize the left colon thus giving the diseased segment an opportunity to subside. Certainly diversion of the fecal stream by divided colostomy is more satisfactory to the patient. It has been our observation that conservative medical measures have

frequently been followed far too long, prior to initiating decompression

There are instances of healing of the diverticulitis, acute or chronic, and closure of the cecostomy or colostomy must be considered, one should be certain that the constricting lesion of the descending colon or the sigmoid has loosened to permit of a comfortable passage of fecal matter through this area before closure is carried out. Closure of colostomy was done in four patients in our group.

Fistula—The distressing complication of fistula formation is not infrequent. Even before surgical intervention fistulous openings may form, burrowing their way through the anterior abdominal wall, or into the urinary bladder, or into the loop or loops of adjacent intestines. Following incision and drainage of peridiverticular abscess grave apprehension is felt as to whether or not a fistulous tract will form, as it has been said that "many close spontaneously but some do not." These fistulous tracts to the anterior abdominal wall are at times troublesome. Numerous attempts are made to close the opening by the injection of various drugs such as sulfonamides, lipiodol or penicillin. Repeated curettage of the fistulous tract has been carried out usually without success. If this discharging opening becomes too much of an annoyance to the individual he may in some instances submit himself to further operative procedures such as resection of the fistulous tract and an attempted closure of the opening of the bowel wall or even resection of the segment.

The fistula into the bladder demands surgery. Assuredly colostomy is advisable to divert the fecal stream from the bladder. We believe with Dixon⁴ that a resection of the involved segment of the bowel with the adjacent tract into the bladder must be carried out before a cure is obtained. Certainly before any measure at all is taken to close these colovesical fistulas, diversion of the fecal stream is essential.

Mortality—When the disease progresses to the stage where surgery is indicated a moderate mortality can be expected, no matter when the surgical procedure is carried out or what it is. This is especially true in those instances of perforation with diffuse peritonitis or even with abscess formation. Incision and drainage alone will give the lowest mortality. In individuals in whom a resection can be carried out as an elective measure and the patient can be properly prepared with a divided colostomy above, there is no reason to expect a high mortality.

SUMMARY

An analysis was made of thirty nine cases of diverticulitis in which operation was done over a period of eleven and a half years. The patients were selected for operation from 131 patients suffering from the disease and being treated on the various services of The Roosevelt Hospital. There were six deaths, a mortality rate of 15.3 per cent.

Most patients treated conservatively by medical management recovered. There are certain of these who will have recurrent attacks and in them resection and a quiescent period will be justifiable.

The patients demanding emergency surgery are those suffering from acute perforation or obstruction. Those having fistulous openings into the abdominal wall, the urinary bladder or a loop or loops of the bowel can be cured by surgical means.

Cecostomy is satisfactory and is safer than colostomy in the cases of acute obstruction.

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PERFORATING WOUNDS OF THE RECTUM

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PERFORATING wounds of the rectum, even when uncomplicated by perforations of the intraperitoneal viscera and peritonitis, are attended by a high mortality and morbidity rate.¹ The reasons for this have become obvious, from an analysis of the battle casualties we have had the opportunity to study and treat during the past three years.

VULNERABILITY OF THE RECTUM TO INJURY AND INFECTION

The rectum is for the most part a retroperitoneal and infraperitoneal organ. The cellular areolar tissue about it is particularly prone to spreading infection. Moreover, the constitutional effects from this infection, referred to by World War I authors as 'colon septicemia,'² are profound, since this tissue is poorly adapted to limitation of the infectious process and is richly supplied with lymphatics.

In other respects, also, the rectum is highly vulnerable.³ It is ensheathed in a condensation of fascia, the endopelvic fascia, which may deflect the missile to produce extensive longitudinal lacerations, or direct contusions eventually resulting in infarctions. Furthermore, the blood supply of a large part of the rectum is from a terminal artery closely applied to its posterior wall, so that injury to this wall readily results in infarction of the rectum distal to the point of trauma. Moreover, large and numerous vessels traverse the infraperitoneal space, in their course to and from the lower extremities, and the highly vascular pelvic viscera, so that extensive infraperitoneal hemorrhages commonly follow perforating pelvic wounds. Hematomas readily track upward into the retroperitoneal space thus aiding in the spread, over a wide area, of infection from a perforating wound of the rectum. Injury to the lumbosacral plexus is not a rare complication, it occurs especially to the nerve roots in injuries of the corresponding lumbosacral vertebrae. If the bladder is full at the time of injury, and the missile traverses anterior to the rectum, there may be an associated perforation of the floor of the bladder, and rarely of the lower ureter.

While the damage to these vital organs within the pelvic cavity is paramount, the injury to the pelvic wall delivered by the missile en route must not be overlooked. Quite commonly there is a fracture of the osseous framework of the pelvis, more rarely the fracture involves the hip joint itself. In addition the missile passes through many fascial compartments, probably leaving behind, in one or more of

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these, foreign bodies or devitalized contaminated tissues which may eventually result in cryptogenic abscesses. These, in the presence of more obvious lesions, may not become manifest until they point in some distant location.

THE PROBLEM OF EARLY DIAGNOSIS

Most of these injuries increase the morbidity, but once the casualty recovers from primary shock, they are not likely to result in the triad of sepsis, malnutrition and death, particularly if perforation of the bladder, and especially of the rectum, is recognized early and properly treated. However, perforating wounds of the pelvis present a special problem in establishing an early and complete diagnosis.

The extent of the damage caused by such wounds can rarely be visualized directly, as in the case of intraperitoneal injuries by a simple surgical exploration, yet it is quite important that a diagnosis be made with no unnecessary trauma, as soon as the patient has been treated for primary shock. Neither absence of clinical shock nor rapid recovery from shock is a guarantee that a perforation of the rectum with coexisting injuries to vital structures is not present.

In establishing an exact diagnosis of the injury, knowledge of the approximate course of the missile is invaluable in the first evaluation of the fresh casualty. It is often overlooked later in the clinical course when it might well explain some of the late complications. If the wound be penetrating, rather than perforating, anteroposterior and lateral roentgenograms by locating the missile will indicate its course. In fact, roentgenograms of the pelvis and abdomen should be taken in all penetrating wounds of the thighs.

Digital examination will often reveal a low, and proctoscopic examination a higher, perforation of the rectum. The presence of blood within the lumen of the rectum is strong presumptive evidence of perforation. Debridement of wounds of the buttock may lead directly to the location of a laceration in the wall of the lower rectum or by its course, indicate the presence of such a laceration. Careful examination of the abdomen often reveals urgent clinical signs in perforating wounds of the pelvis, even in the absence of intraperitoneal injury. The patient with such a wound should be catheterized. The presence of grossly bloody urine should be considered suggestive evidence of a perforating wound of the bladder.

PROMPT AND ADEQUATE SURGERY IS INDICATED

The secret of the greatly lowered mortality and morbidity rate in perforating wounds of the rectum in this war lies only partly in the excellent and early supportive measures our soldiers received soon after injury—abundant whole blood and plasma to restore the effective blood volume and thus hasten recovery from shock. To a much

greater extent it lies in the application of prompt and expeditious prophylactic surgery. In the absence of such surgery our modern chemotherapeutic and supporting agents, even when assiduously administered, have not been able to stem the tide of sepsis with its secondary cachexia and death.⁴

Prompt and expeditious prophylactic surgery of perforating wounds of the rectum locates and saucerizes the site of perforation and effectively by-passes the fecal stream as soon as possible after the treatment of primary shock. By removing the coccyx and, if necessary, the lowest sacral segment, and then incising the pre-coecygeal fascia, the rectum may be stripped upward posteriorly and laterally until the laceration is exposed and sutured. The infraperitoneal spaces are then loosely packed.

A laceration of the rectum may often be reached through the levator and its investing fasciae in the débridement of a wound of entrance on the surface of the buttock. However, the accessibility for suture of the laceration and the adequacy of drainage of the infraperitoneal perirectal space are vastly improved by coccygectomy.

While free drainage will prevent spreading infraperitoneal sepsis and death, suture of the laceration of the rectum is advised, if conditions permit, to preclude the formation of a chronic rectal fistula and thus obviate later surgery.

Since perforating wounds of the rectum, even in the absence of infraperitoneal injury, are often associated with urgent lower abdominal signs, sigmoid colostomy without exploratory celiotomy is seldom justifiable. A large infraperitoneal hematoma, raising the peritoneal floor of the pelvis, is commonly the only finding on exploration. If the peritoneum is not lacerated so that the peritoneal cavity remains uncontaminated, sigmoid colostomy is the only intraperitoneal procedure indicated.

If the pelvic peritoneum is lacerated, and evidence points to a high perforation of the rectum or the floor of the bladder, the peritoneum may be further incised and reflected, the perforations sutured if possible, and the peritoneum resutured after securing adequate drainage below. Sigmoid colostomy is then established through a left gridiron incision. If required, a suprapubic cystostomy with adequate drainage of the space of Retzius is done through the caudal half of the exploratory incision. In case the sigmoid is long and sufficiently mobile, a spur type of colostomy is preferred. It prevents the spilling of fecal contents into the rectum more effectively than the loop type of colostomy.

REPORT OF TWO CASES

The importance of prompt and adequate surgery in determining the clinical course following perforating wounds of the rectum is well illustrated in the following cases:⁴

CASE I.—A 32 year old soldier sustained a mortar shell fragment wound of the left buttock on April 8, 1944 at 6 30 P. M., while in his company area. He tried to walk to his quarters, but collapsed. He was transferred to a field hospital where operation was performed a few hours later.

Under endotracheal ether anesthesia, the wound of the left buttock was debrided and perforated. An incision, the coccyx in the infraperitoneal position and through a lower left rectus incision the peritoneal cavity was opened and several perforations of the ileum repaired. Then a spur type of sigmoid colostomy was performed through a left muscle splitting incision.

The postoperative course was almost entirely satisfactory. There was some delay in the healing of the transcoccygeal wound due to a sequestering osteomyelitis of a small segment of remaining coccyx. A sequestrectomy was performed on May 9, 1944 and thereafter the wound healed uneventfully. The patient was transferred to the Zone of Interior on July 23, 1944.

On admission to Halloran General Hospital the patient's general condition was good. The sigmoid colostomy was functioning well, the operative wounds were healed and he had no complaints. Barium studies of the large bowel and proctoscopic examination revealed that the perforation was healed. Laboratory data were normal. After a period of observation and further recuperation, the colos-

CASE II.—A 23 year old soldier sustained a penetrating gunshot wound of the left buttock on March 27, 1943. The bullet lodged in the bodies of the first and second sacral vertebrae. Laparotomy was performed the following morning through a lower left rectus incision. As an intraperitoneal lesion was not found, the wound was closed without drainage and without colostomy. The immediate postoperative course was very stormy. The laparotomy wound became infected and was widely opened. Frank fecal discharge appeared from the wound of entrance in the left buttock. Despite vigorous supportive treatment the patient became very ill and rapidly cachectic.

When the patient arrived at Halloran General Hospital on April 30, 1943, he was severely septic and emaciated. The laparotomy wound was superficially

Laboratory data revealed moderate anemia despite numerous transfusions. Roentgenograms demonstrated a bullet lodged near the right sacroiliac joint.

On May 6, 1943 incisions were made in the left buttock to improve the drainage of the fecal abscess. On May 11, 1943 the mass in the right lower quadrant of the abdomen was incised and found also to be a fecal abscess.

Subsequent roentgenograms after lipiodol injection through this incision revealed a communication with the infraperitoneal space. Barium enema disclosed a large perirectal abscess communicating on the one hand with a perforation of the rectum and on the other with the right inguinal abscess. Barium meal showed no evidence of an internal fistula from small bowel or cecum communicating with

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buttock lost its fecal character large amounts of malodorous pus continued to discharge from these incisions On August 2 1943 the discharge from the right inguinal region resumed a fecal character and it was presumed that an internal fistula had now developed from ileum cecum or ascending colon On August 9 1943 the discharge became bloodstained and on August 10 following profuse hemorrhage from the incisions in the right inguinal region and the left buttock the distal colostomy orifice and the rectum the patient expired

Postmortem examination revealed marked emaciation The peritoneal floor of the pelvic cavity had been raised by the underlying necrotizing infection of the infraperitoneal space This infection had extended anteriorly about the bladder It communicated with the abscess lying between the gluteal muscles through the bullet tract in the left levator muscle There was a perforation of the rectum in its posterior wall about 8 cm above the anal orifice The bullet lay embedded in a crumbled mass of cancellous bone in the bodies of the first and second sacral vertebrae Thence the fecal abscess had extended upward along the right iliac fossa almost to the liver About midway in the posterolateral wall of the ascending colon it had established a large secondary fistula We presume that this fistula was secondary since it did not lie in the path of the missile and because no fecal discharge appeared from the right inguinal incision for almost a month after the sigmoid colostomy had been established There was a septic erosion of many visceral branches of the pelvic vessels but the exact origin of the hemorrhage could not be located

Comment—We have presented, by way of contrast, the clinical courses of two battle casualties with perforating wounds of the rectum Fortunately, the clinical course illustrated by the second case has been the exception Imperfections in early treatment have been minor leading to increased morbidity rather than death

Both cases were given excellent early supportive treatment The first received in addition however early and adequate prophylactic surgery consisting of proximal colostomy and coecogectomy to allow suture of the rectal perforation and saucerization of the infraperitoneal space The second received inadequate treatment following the injury Late surgery alone may be unable to overtake the complications attendant on rectal perforation Supportive measures such as whole blood, plasma and chemotherapeutic agents even when used vigorously, are in no way a substitute for, but merely adjuvants to intelligent surgery

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SURGICAL DIAGNOSIS OF ACUTE INJURIES OF THE KNEE JOINT

G BLUNDELL JONES MD FRCS (ENG) FRCS (EDIN)*

INTRODUCTION

This paper is based on observations on 200 cases of acute injury of the knee joint exclusive of wounds and open fractures sustained by fit men of the British Second Army in the advance from Normandy into Germany. The majority of these were men who had no history of previous injury of the joint were front line troops of high medical category and sustained their injuries in a multiplicity of ways. It was of the greatest importance to arrive at an accurate diagnosis of the nature and extent of the lesion from the point of view of probable length of incapacity and in order to allow as many as possible to receive intensive treatment to render them fit for early return to duty. Those with a probable incapacity lasting over five or six weeks were evacuated to a base and the remainder treated in the forward area of the latter 90 per cent returned to duty in their original category. Although they could not be traced afterwards the return rate through hospital was not more than 2 per cent. It is to be emphasized that the surgeon dealing with the primary joint injury is always in a better position to discover the nature and extent of the lesion than anyone at a later stage that he should record his exact findings for the benefit of anyone dealing with the later stages and that upon his diagnosis rests the application of precise treatment to insure the best possible eventual outcome. A careful method in examination of such a complicated joint is essential to discover the whole story of damage done and certain valuable diagnostic points will be considered with a brief reference to treatment and prognosis.

HISTORY OF THE INJURY

The importance of obtaining the patient's detailed account of the mechanics and severity of his injury cannot be overstressed and it is often possible to arrive at a probable diagnosis on this alone.

Main Types of Injury—There are four main types of injury 1 *Abduction, Flexion and External Rotation of the Tibia*—This is the commonest mechanism in football sking running over rough ground and jumping in battle the foot being fixed by obstruction while the momentum of the body inward and rotating medially produces the lesion. This violence produces first a stretching or partial tearing of

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the internal lateral ligament, then a rupture, complete or partial, of the anterior cruciate ligament often together with the posterior cruciate ligament according to the degree of flexion. In addition, the internal semilunar cartilage is often torn with displacement. Varying severities of each of the above lesions make the combined picture. Sometimes fracture of the external tibial condyle occurs, often with minimal ligamentous damage.

2 *Abduction, Flexion and Internal Rotation of the Tibia*—This is not a common mechanism but is seen in motorcycleists, footballers and skiers. The external lateral ligament may be sprained or ruptured, followed in increasing violence by injury to anterior cruciate ligament, external cartilage and the tendon of the popliteus. The peroneal nerve may also be injured.

3 *Hyperextension*—The knee is forced into hyperextension by force applied to the extended leg. With increasing violence the posterior capsule may be torn, partial injury of the posterior cruciate follows and then the major injury, rupture of the anterior cruciate ligament with or without avulsion of a fragment of bone at its tibial insertion.

4 *Forcible Backward Displacement of the Tibia*—This is seen in motorcycleists and is a dashboard injury in vehicle crashes. The posterior cruciate ligament is torn and may be avulsed with a fragment of bone from the tibial attachment which is drawn through the posterior capsule into the joint. Or the whole tibial spine may be elevated.

Other Injuries—Other injuries worthy of mention are 1 *Direct Contusions*—These produce persistent local effects particularly in the region of the infrapatellar pad of fat and insertion of patella tendon, hemarthrosis often accompanies them. Stellate and crack fractures of the patella are not uncommon.

2 *Repeated Small Traumas*—Men riding and working in tanks receiving multiple blows on the flexed knee often show persistent painful synovitis. This condition also occurs in miners.

3 Muscular violence of the quadriceps will cause patella fracture with separation—a direct blow is often added at the same time. One case of avulsion of the quadriceps from the patella was seen in the present series.

4 Men undergoing continual severe exertion, such as mountain troops, may develop fatigue changes on the patellofemoral articular surfaces producing 'hot spots' or chondromalacia patellae (Owre, 1936). Two such cases occurred in the series.

CLINICAL EXAMINATION

A routine method should be adapted, both legs being fully exposed from the groins, and the following is suggested.

1 *Inspection*—general appearance of knee, position held for comfort, quadriceps measurement for wasting and bone and selective wasting if present.

2 Effusion—amount recorded by sign, diagnosed by fluctuation and patella tap Local temperature of the joint is important and hemarthrosis will be recognized by heat, tenderness and baggy feeling The body temperature is often raised with hemarthrosis

3 Points of acute tenderness—over joint line and ligaments In the acute phase these are of only general value but afford much more precise evidence as the joint settles

4 Range of movement and its limitation by pain Active and passive

5 Stability—always tested in comparison with the opposite side to rule out individual variation Lateral mobility should be tested in 10 degree flexion and full extension, anteroposterior mobility in 90 degree flexion with muscular relaxation

6 Manipulations—rotation in flexion McMurray's test Rotation in 20 degree flexion Clicks and thuds produced by cartilage lesions are noted This is rarely possible in acute injury as relaxation is prevented by pain

All the above should be checked by comparison with the opposite knee and recorded in detail It is not always possible to obtain full information at the time of the first examination but it can often be gathered in subsequent days by careful examination and the value of accurate previous records is here apparent

RADIOLOGICAL EXAMINATION

This must *never* be omitted in joint injuries, however certain the clinical findings appear Normal two-plane films will suffice generally but it may often be of advantage to assess the amount of ligament damage by taking the joint in the deformed position and measuring the abnormal widening present Ligamentous injuries are often associated with avulsions of bone attachments and may be complicated by fractures of the condyles In addition, all those who have seen many injuries will agree that occasionally surprising lesions can be discovered only by x rays I quote five examples from the present series

1 A "rotation sprain" x raved three weeks after injury because of slow recovery was found to be a fracture of the external condyle of the tibia, fortunately undisplaced

2 A recurrent locking knee with all the signs and symptoms of a lesion of the internal cartilage was shown radiologically to be due to an osteoclastoma of the tibia Operation had been performed (not by the writer!) without x ray and a normal cartilage removed The appearance of the tibial articular cartilage explained the mechanics of locking

3 An acute strain of the internal lateral ligament led to the discovery of an osteogenic sarcoma of the lower third of the femur

4 A perforating bullet wound of the quadriceps not involving the

knee joint was found to have a large area of osteochondritis dissecans of the medial femoral condyle and a large loose body

5 A symptomless Brodie's abscess of the femur was discovered in a rotation sprain and later caused persistent effusion

EXAMINATION UNDER ANESTHESIA

Severe injuries which are very painful may not have been completely diagnosed by the above routine. Gentle manipulation under pentothal anesthesia after aspiration of effusion will reveal lateral ligament and cruciate ruptures, and loss of extension due to cartilage displacement. The anesthetic also allows of painless aspiration of hemarthrosis and of reduction of displaced cartilages. If ligament rupture is present it is important to know its extent and either plaster immobilization or operation will be decided upon. It has been my practice to immobilize partial ruptures in groin to ankle plaster for eight weeks and to operate on complete ruptures of the lateral ligaments. A permanent record of the degree of abnormal mobility may be made at this examination by x-rays taken with the joint in the deformed position. This is not essential since the diagnosis is complete on clinical grounds. The surgeon should now be in a position to give a precise statement of the structures injured.

CLASSIFICATION OF KNEE JOINT INJURIES

Salient Features of the Commoner Lesions—*Internal Lateral Ligament*—The tearing may be partial or complete, isolated or combined with other lesions

1 Pain is felt over the inner aspect of the joint, becoming more severe some hours after injury. It may be less severe in complete ruptures than in sprains.

2 There is inability to extend the knee fully—this is first voluntary for comfort and later due to hamstring spasm.

3 Pain is increased by abduction, hence lying with leg on the outer side is most comfortable, it is also increased by full extension.

4 Acute tenderness over site of injury may be well localized to the ligament.

5 With relaxation either under anesthesia or gaining the patient's cooperation abduction rocking in 10 degree flexion is increased. If rocking is present in full extension under anesthesia the anterior cruciate is probably torn in addition (Palmer, 1938).

6 Swelling with bleeding into the joint may or may not be present. It depends upon concomitant synovial injury and if the rent is large the effusion may not accumulate but a general hematoma forms in all tissues around the joint. This is a trap for the unwary.

7 It may not be possible to exclude displaced internal cartilage preventing full extension without examination under anesthesia after as-

piration. If extension is still limited when reflex spasm is abolished and the fluid removed then a displaced cartilage is resisting it.

External Lateral Ligament—The commonest site of injury is the inferior insertion and is often accompanied by avulsion of a bone fragment from the fibular head. The biceps insertion may also be avulsed. The clinical picture is much as for the internal ligament described above as a mirror image reversed. The occurrence of peroneal palsy should be borne in mind.

Cruciate Ligaments—Isolated injuries are uncommon. In a rupture of either ligament there is a feeling of complete insecurity when the knee moves into flexion. When the anteroposterior mobility of the tibia on the femur is tested with the knee at a right angle and the muscles relaxed, abnormal forward mobility compared with the other side indicates anterior cruciate injury, whilst abnormal backward shift denotes injury to the posterior ligament. The sign referred to the anterior ligament is often only present in nonanesthetized patients early after injury, as later hamstring spasm prevents it. Cruciate injuries are often accompanied by bone avulsions from the tibial spine or a raising of the whole spine, and x-ray examination is essential. Those interested in the anatomy and mechanics of the ligaments of the knee joint in detail should consult Palmer's clinical study (1938).

Combined Injuries—Various combinations of the ligament injuries occur in the multiplicity of violences that come to the knee joint in our mechanized existence, and the motorcycle is highly productive of these. With ligament tears often meniscal lesions are found and fractures of the condyles of the femur and tibia. Perhaps commonest of all is the combination of internal lateral and anterior cruciate ligament tear with rupture of the internal meniscus produced by the abduction flexion external rotation strain. This combined injury is responsible for a large proportion of permanently disabled knees and bad results following meniscectomy. Proper initial treatment will do much to minimize the eventual disability.

Types of Lesions—It is convenient to divide ligamentous injuries into three groups: (1) minor partial ruptures or sprains, (2) partial ruptures, (3) extensive and complete ruptures. These may be isolated or combined and are classified as such and may be complicated by fracture or meniscus lesion.

A precise diagnosis should now be made of which these are two examples: (1) Isolated minor partial rupture of internal lateral ligament (sprain). (2) Complete rupture of internal lateral ligament, partial rupture of anterior and posterior cruciate ligaments, complicated by torn displaced internal meniscus.

Any one of the injured structures may show a complete tear while others are only partial, e.g. it is possible to tear the internal cartilage with minimal ligamentous injury.

Having arrived at a precise diagnosis it is now possible to prescribe precise treatment

ANALYSIS OF 200 CASES OF ACUTE KNEE INJURY

CAUSATION

Football (Association)	65
Battle accidents (jumping from tanks and vehicles, falls into holes, etc.)	43
Motorcycle accidents	30
Vehicle crashes	17
Miscellaneous	45

DIAGNOSIS

1 Minor partial ligament injury (sprains)		99
(a) Isolated	Internal lateral	42
	External lateral	12
(b) Combined	Abduction external rotation type	31
	Others	14
2 Partial ligament ruptures		25
(a) Isolated	Internal lateral	14
	External lateral	2
(b) Combined	Abduction external rotation type	8
	Others	1
3 Complete ligament ruptures		19
Combined	Internal lateral and cruciate	13
	External lateral and cruciate	6
4 Contusions and traumatic synovitis		38
5 Miscellaneous		19
Fractured patella		7
Dislocation patella		2
Fracture tibial condyle		4
Rupture quadriceps tendon		1
Others		5

Lesions of the menisci were definitely diagnosed in eighteen of the combined injuries—sixteen internal and two external

TREATMENT

1 Operative—This will be necessary immediately only in a small group of cases and they are mainly (a) the complete lateral ligament ruptures and (b) the displaced irreducible meniscal lesions. Cruciate ruptures are almost always incapable of repair but occasionally avulsion of bone fragment from the attachment may need operative replacement. In the present series five cases of lateral ligament rupture (three internal, two external) were subjected to operation. Others were evacuated for treatment elsewhere. The finding of ragged in-rolled ends with separation such as to render healing impossible without much scar and laxity is usual, and excellent approximation is secured by simple suture alone or reinforced by fascial graft. One external lateral ligament rupture showed also avulsion of the biceps insertion. Post-operative immobilization in plaster is continued for eight weeks.

2 Plaster immobilization—This is used for the partial rupture with

piration. If extension is still limited when reflex spasm is abolished and the fluid removed then a displaced cartilage is resisting it.

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Any one of the injured structures may show a complete tear while others are only partial, e.g., it is possible to tear the internal cartilage with minimal ligamentous injury.

But exercises must be continued until full normality is reached in three to six months or more. To leave off too soon results in a joint incompletely protected by muscle control and coordination which consequently sustains repeated minor traumas in ordinary use and later develops osteoarthritis.

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THE DIAGNOSIS OF NEOPLASMS OF BONE

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Prior to the last half century clinicians were compelled to make a diagnosis of a lesion of the skeletal system entirely on basis of the patient's history and the physical examination. They did not have the assistance of the roentgenologist nor of the pathologist's accurate interpretation of tissue sections. Since that time, however, due to developments in the fields of pathology, roentgenology and chemistry, the identification of these tumors has been rendered more possible. This does not mean that a correct diagnosis is made in every case. On the contrary one is impressed with the number of patients who have been incorrectly treated on an erroneous diagnosis or have received no therapy at all because the diagnosis has not been reached.

The approach to the problem of establishing a diagnosis in a lesion of the skeletal system implies the following steps:

- 1 History
- 2 Physical examination
- 3 Roentgenographic examination
- 4 Blood chemical studies
- 5 Histologic examination

HISTORY AND PHYSICAL EXAMINATION

The importance of a carefully elicited history and a complete and searching physical examination should be emphasized since the tendency is to neglect them in favor of other diagnostic measures. Both are as important today as they were when they comprised the only known means of diagnosis. They are still the foundation upon which the various other investigations must rest. Neglect of them continues to result in serious errors of interpretation of roentgen ray and laboratory findings, or postponement of these tests which is fully as grave in its consequences.

Probably the one single factor that would tend to an earlier recognition of bone sarcoma is the general knowledge on the part of the practitioner that *pain* is the earliest and most constant symptom, and that a patient complaining of pain in an extremity deserves a presumptive diagnosis of sarcoma with an immediate diagnostic survey (Table 1) to confirm or exclude it. Such suspicious attitude would prevent the lapse of weeks or months, during which period many patients receive therapy consisting of massage, heat, liniments, diath-

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TABLE 1—OUTLINE OF A COMPLETE DIAGNOSTIC SURVEY TO BE UNDERTAKEN WHEN THE INITIAL EXAMINER SUSPECTS THE PRESENCE OF A BONE NEOPLASM

- 1 Elicit a complete *History* covering the following
 - A Chief complaint {
 - pain (character—nocturnal)
 - swelling
 - disability
 - B Onset of symptoms (sudden—insidious—progressive—intermittent)
 - C Previous illnesses
 - D Accidents or Injuries
 - E Family History
 - 2 Make a thorough *Physical Examination*
 - A General
 - (1) Primary tumor elsewhere (breast—thyroid—kidney—prostate etc)
 - (2) Evidence of deformed skull or long bones, neurofibromatosis, pigmentation, lymphadenopathy, splenomegaly, anemia
 - B Local
 - (1) Inspection (swelling deformity, color of skin presence of tumor and its location in respect to the part of bone involved)
 - (2) Palpation (presence of tumor, its mobility, consistence [hard—soft—elastic—fluctuant—pulsating] outline [discrete or indefinite])
 - (3) Mensuration (circumference of the limb at measured levels, and of the normal limb for comparison)
 - 3 *Röntgenographic Examination*
 - A Local (views of the affected area in anteroposterior and lateral projections on films large enough to cover wide area proximal and distal to area complained of or to site of any obvious tumor)
 - B General
 - (1) Chest—anteroposterior and lateral—for evidence of pulmonary metastasis
 - (2) Other bones, especially skull, pelvis, spine, humeri and femora
- Note* Spot films of the involved bone taken in several projections and with varying degrees of intensity of exposure are valuable
- 4 *Laboratory Studies*
 - A Routine blood count
 - B Urinalysis (including test for Bence Jones bodies)
 - C Serology
 - D Blood chemistry
 - (1) Serum calcium, phosphorous alkaline phosphatase (including acid phosphatase if cancer of prostate is suspected)
 - (2) Serum protein (if plasma cell myeloma is a possibility)
 - E Biopsy
 - (1) Aspiration biopsy
 - (2) Open biopsy if aspiration method is unsuccessful or if it is not considered advisable for reasons of location of tumor or unwillingness on the part of the pathologist to render an opinion on aspirated material, or failure of aspiration to provide a diagnosis

erny and even exercise on the assumption that the condition is "rheumatic" or "neuritic" or a strain of muscle or ligament. It has been repeatedly emphasized that pain in a limb that persists without obvious explanation is most often due to a bone tumor.

Swelling usually appears later than pain. Both are progressive, although there is considerable variation in the rate of increase of the

swelling depending upon the individual tumor's cellularity and its capacity for growth. Disability is also variable although it is present in most cases in some degree even early in the course of the disease. Benign tumors, on the contrary, seldom cause severe pain. When they do, it is because of pronounced pressure on important overlying structures. Such tumors rarely cause pain while the part is at rest in contrast to malignant tumors which often keep the patient awake at night. Swelling in a benign tumor is either stationary or increased by insensible gradations, often it is reported by the patient to have existed unchanged for years. A history of recent rapid increase in size or complaint of recent pain should suggest malignant transformation.

Any injury sustained prior to the onset of symptoms should be recorded in detail by the initial observer, for whether it is held to be responsible for the subsequently developing tumor or considered to be of no etiological significance is still a matter of controversy. While the patient often ascribes it as a cause of the disease, competent authorities are skeptical of its influence. Ewing, Stewart and others have expressed the conviction that a single trauma cannot be credited with initiating a malignant process. It seems probable that in the vast majority of cases the injury focused the patient's attention on a region already the site of a neoplastic process. However, I believe that we are not wholly justified in denying categorically the possibility that a localized bone trauma can initiate reparative processes which, under certain conditions, may lead to unrestrained growth and eventually to the development of a bone sarcoma, especially in view of the fact that approximately 50 per cent of the histories of cases of osteogenic sarcoma record a definite injury at the site of the subsequent tumor.

I hold even stronger convictions that injury is an important etiological factor in the development of giant cell tumor of bone—a view also held by William B. Coley, Codman and others.

It becomes at once apparent that *first*, such cases may be the subject of future litigation, and *second*, that a fairer disposition of them can be made if the initial examiner's history has been elicited fully and accurately, presumably at a time when the patient's replies to questions are not so apt to be colored by self-interest. The records should include answers to the following questions:

- 1 When did the injury or accident occur?
- 2 Where was the exact site of the injury?
- 3 Was the injury followed by swelling, tenderness or ecchymosis?
- 4 How long a period elapsed between the disappearance of symptoms due to the injury and the appearance of symptoms referable to the tumor?

The characteristics noted on physical examination that denote a benign tumor of bone are: absence of soft-tissue involvement, discrete sharply-defined outline, absence of skin changes, lack of increased vascularity as shown by dilated superficial veins and increased surface

TABLE 2—DIAGRAM SHOWING METHOD OF DIFFERENTIAL DIAGNOSIS BY EXCLUSION IN A CASE OF BONE DISEASE

TUMOR			
Benign	Central	Chondroblastoma (Jaffe)	
		Chondroma	
		Myxoma	
		Fibroma (nonosteogenic—Jaffe)	
		Bone cyst	
	Central and cortical	Giant cell tumor, benign	
		Xanthoma	
	Central and cortical	{ Angioma of bone	
		{ Osteoid osteoma	
	Cortical (osteoma)	{ Exostosis	
{ Osteochondroma			
{ Multiple—chondrodysplasia (Ollier's disease)			
Malignant	Primary	Monostotic	Osteogenic sarcoma
			Endothelioma (Ewing's sarcoma)
			Reticulum cell sarcoma
			Liposarcoma
		Polyostotic	Plasma cell myeloma
			Mielocytoma
	Metastatic	{	Breast
			Kidney
			Thyroid
			Prostate
			Lung etc
NOT A TUMOR			
Inflammatory	{	Pyogenic (Brodie's disease)	
		Luetic	
		Tubercular	
		Chronic sclerosing osteitis	
Posttraumatic—Myositis ossificans			
Parasitic—Hydatid disease of bone			
Metabolic—Lipoid granulomas	{	Eosinophilic granuloma	
		Hand Schuller Christian's disease	
		Gaucher's disease	
		Niemann Pick's disease	
		Letterer Siwe's disease	
Circulatory—Calcinosis			
Endocrine—Hyperparathyroidism (Von Recklinghausen's disease)			
Uncertain Etiology	{	Paget's disease (Osteitis deformans)	
		Fibrous dysplasia	
		Melorheostosis	
		Osteopetrosis	
		Osteopoikilosis	

temperature The location of the swelling is of some significance, for giant cell tumors have a nearly constant onset at the ends of long bones, osteogenic sarcoma shows a marked predilection for the metaphyseal region, and endothelioma, which may also commence in this region, tends to progress along the diaphysis and to involve one fourth to one half of the entire length of the bone Tenderness, although usually only in mild degree, is a finding in malignant tumors which is seldom present in benign neoplasms

Table 2 shows in diagrammatic form the method of approach adopted at the Memorial Hospital in establishing the diagnosis While many of the conditions listed are admittedly unusual or even rare, we feel that they should be borne in mind

ROENTGENOGRAPHIC EXAMINATION

The roentgenographic examination while of great value and capable of comparatively accurate interpretation by experienced roentgenologists, is still attended by certain difficulties There are many conditions in which it is almost impossible to render an accurate opinion by this means alone as shown in Table 3

TABLE 3—THE DIFFERENTIAL DIAGNOSIS OF BONE TUMORS, WITH PARTICULAR REFERENCE TO THE ROENTGENOGRAM AS AN AID

Actual Diagnosis	To be differentiated from
Osteogenic Sarcoma	<i>Endothelioma</i> when wide extent of shaft especially mid portion is involved <i>Giant Cell Tumor</i> when purely osteolytic and when area of destruction is confined to epiphyseal area which is the site of giant cell tumors <i>Liposarcoma</i> although it is extremely infrequent A roentgenographic distinction may be very difficult <i>Inflammatory Bone Lesions</i> sclerosing and low grade subacute osteomyelitis <i>Ossifying Hematoma</i> (myositis ossificans) unless stereoscopic views are taken showing process to be unconnected with shaft of bone and the cortical line is intact <i>Metastatic Carcinoma</i> When lesion is apparently solitary it may resemble osteolytic sarcoma <i>Chondroblastoma</i> (Jaffe) <i>Calcifying Chondromatous Giant Cell Tumor</i> (Codman) This is a difficult distinction to make and must depend ultimately upon biopsy <i>Reticulum Cell Sarcoma</i> Where an osteogenic sarcoma is of osteolytic type it may require histological confirmation to establish the correct diagnosis This is particularly true of lesions involving the metaphyseal area Those occurring in the midshaft are more likely to prove reticulum cell sarcoma

- Endothelioma** *Subacute Osteomyelitis* This is a most difficult differential diagnosis to make. When uncertainty exists, histologic proof should be obtained *before* any roentgen therapy is given, otherwise a 'false negative' biopsy is often obtained and only at a later date is the malignant nature recognized.
- Osteogenic Sarcoma* (see under Osteogenic Sarcoma)
- Reticulum Cell Sarcoma* This diagnosis may be very difficult if the patient is below 30 years of age. Reticulum cell sarcoma can occur at any age, while endothelioma is confined to childhood and early adult life.
- Giant Cell Tumor** *Bone Cyst* The site, age of patient and clinical course differ.
- Malignant from Benign Giant Cell Tumor* Generally the malignant form is a transition from a previously benign giant cell tumor. This means that during or after treatment, a recurrence of activity is suggestive that the lesion is undergoing malignant transformation. Cases that are malignant from the outset are rare and the roentgenographic features are often more typical of a malignant central sarcoma than of a benign giant cell tumor.
- Calcifying Chondromatous Giant Cell Tumor* (Codman), *Chondroblastoma* (Jaffe) These tumors more closely resemble an osteogenic sarcoma but may occasionally suggest a giant cell tumor. They are benign. A biopsy is needed to establish the diagnosis.
- Osteogenic Sarcoma* (see under Osteogenic Sarcoma)
- Chondrosarcoma** *Chondroma* This may require expert microscopical diagnosis. Small bits of tissue are not sufficient material upon which to base an opinion.
- Giant Cell Tumor* Central chondromyxosarcoma may closely simulate giant cell tumor. This accounts for some discouraging sequelae of radiation therapy of supposed giant cell tumor without histologic diagnosis.
- Osteogenic Sarcoma* May be very difficult to distinguish from chondroblastic sarcoma in children or young adults. Distinction here is not important. The treatment is the same and the outlook equally grave.
- Chordoma* Rarely seen may resemble sacral chondrosarcoma. Microscopical appearance of chordoma is distinctive.
- Plasma Cell Myeloma** *Metastatic Carcinoma* In the absence of evidence of a primary carcinoma this distinction is often impossible without histologic confirmation. Aspiration biopsy of one of the lesions or sternal marrow puncture may disclose plasma cells and lead to the correct diagnosis.
- See also Figures 208-213

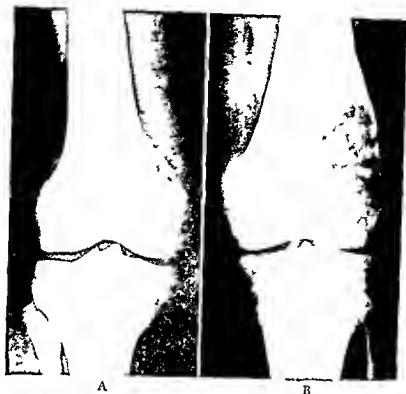


Fig 208—*A* Osteolytic form of osteogenic sarcoma *B* Giant cell tumor



Fig 209—*A*, Plasma cell myeloma *B*, Metastatic thyroid carcinoma.



Fig 210—*A* Central chondroma (endochondroma) *B* Metastatic carcinoma of breast



Fig 211—*A* Metastatic transitional cell epithelioma (pharynx) *B*, Angioma of bone (benign)

The histologic examination is generally conceded to be the final step in establishing the diagnosis not only in all forms of bone neoplasms but in other bone conditions which may resemble them. Unquestionably this is the most reliable single measure at our disposal. It should be understood, however, that even pathologists of wide experience encounter innumerable situations in which an exact micro-



Fig. 212—Chronic sclerosing osteitis. This case had been considered one of sclerosing osteogenic sarcoma. It also closely resembles an osteoid osteoma.

scopical diagnosis is extremely difficult. The following are cited as examples:

- 1 Reticular cell sarcoma *versus* endothelioma
- 2 Undifferentiated small cell osteogenic sarcoma *versus* endothelioma
- 3 Osteogenic sarcoma *versus* early ossifying hematoma myositis ossificans
- 4 Benign giant cell tumor *versus* malignant giant cell tumor

In these difficult decisions it has been noted that the more experienced the pathologist the more willing he is to concede an element of doubt and to refuse to make an unqualified diagnosis. Here, then, the clinical and roentgenographic findings must be carefully weighed with the laboratory evidence. To illustrate, the stereoscopic roentgenogram is of great importance in differentiating an early ossifying hematoma from an osteogenic sarcoma. On three occasions we have

seen this prove more accurate than the microscopical interpretation of material removed by open biopsy. In each of these cases highly qualified pathologists regarded the condition as one of osteogenic sarcoma and in each instance the x-ray diagnosis of ossifying hematoma was ultimately sustained. In another case, a surgeon performed a thigh amputation only to find on later examination of the limb that the biopsy report of osteogenic sarcoma was incorrect.

Two features of ossifying hematoma ought to be emphasized in this connection: (1) the patient does not have the unremitting pain char-



Fig. 213—Huge osteoma of dense almost marble like composition. Histologically benign. X-ray appearance closely resembles sclerosing osteogenic sarcoma.

acteristic of sarcoma, and (2) the tumor fails to increase progressively in size. Moreover it always follows directly upon a severe trauma and fails to cause any break in the cortical line when viewed by stereoscopic roentgenograms.

Of importance, too, is the decision as to whether or not a benign giant cell tumor has undergone malignant alteration. This change may take place insidiously, and successive specimens obtained at several operations may reveal a gradual transition from benign to malignant. It rests with the pathologist to decide at what point a hitherto benign lesion has changed to a potentially dangerous growth with the ability to metastasize and end fatally. Experience has taught us that the recurrent giant cell tumor must be regarded as a disease with a definite

tion therapy has contributed the greater proportion of these cases. Accordingly in these cases our suspicions are at once aroused and we do not countenance too long deferment of histologic study or too great delay for the purpose of further roentgen therapy.

NON NEOPLASTIC CONDITIONS THAT NEED TO BE CONSIDERED IN THE DIFFERENTIAL DIAGNOSIS

There are many conditions which are not true neoplasms and which at times give rise to difficulties in the field of bone tumor diagnosis. Some of these bear only a superficial resemblance while others are often difficult to differentiate. In order to call attention to them they are listed in Table 4 with the corresponding tumor which they may at times resemble.

TABLE 4—NON NEOPLASTIC CONDITIONS OF BONE THAT MAY HAVE TO BE CONSIDERED IN THE DIAGNOSIS OF TUMORS OF BONE

Non neoplastic conditions	May resemble
1 Infections	
Pyogenic	Endothelioma
Typhoid	Myeloma
Syphilis	Almost any form of bone tumor
Tuberculosis	Myeloma of spine synovioma with bone involvement
Chronic sclerosing osteitis	Sclerosing osteogenic sarcoma
2 Parasitic Diseases	Echinococcus disease of bone
3 Fibrocystic Diseases	
Solitary bone cyst (unicameral)	Giant cell tumor central chondroma
Hyperparathyroidism	Skeletal metastases from carcinoma
Fibrous dysplasia	Central chondroma nonosteogenic fibroma
4 Diseases of Uncertain Etiology	
Osteitis deformans	Monostotic form (osteogenic sarcoma)
	polyostotic form (metastatic prostatic carcinoma)
Leontiasis ossium	Low grade sarcoma
Osteoid osteoma	Sclerosing osteogenic sarcoma
5 Lipoid Storage Diseases	
Hand-Schüller Christian's disease	Metastatic carcinoma
Eosinophilic granuloma	Primary osteolytic osteogenic sarcoma
6 Circulatory Disturbances of Bone	
Aseptic necrosis of bone	Chondroblastoma
Calcinosis (tumoral form)	Sclerosing osteogenic sarcoma
7 Disturbances Due to Injury	
Ossifying hematoma (myositis ossificans)	Osteogenic sarcoma
Fatigue fracture (early reparative stage)	Osteogenic sarcoma
Periosteal injuries (early stage)	Osteogenic sarcoma (early)

SUMMARY

In attempting to reach an early correct diagnosis of any lesion of bone suspected of being neoplastic, the history and clinical examination should precede other measures. The value of the roentgenographic, chemical and histologic studies are unquestioned but the necessity of relying on the correlated information gained from all these sources, rather than from any one of them, is emphasized.

INDICATIONS FOR THE SYME AMPUTATION

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THE Syme amputation like most others is not new. It was first described by James Syme of Edinburgh in 1843.¹ Since that time many reports have appeared in the literature on this subject most of them before 1900.

There seems to have always been a keen interest in the Syme amputation among surgeons everywhere but there has been until the advent of the late war a considerable difference of opinion as to the merits of this amputation among even those with a great experience in amputation surgery. Extreme views concerning the Syme amputation have ranged from the best of all major amputations to do not under any circumstances advocate amputation at this level.²

In order to approach and understand the problems and differences of opinion regarding the status of the Syme amputation in the past it is best to divide them into two groups for consideration: (1) war cases or those in which there has been infection and sepsis and (2) civilian or clean cases.

Unquestionably the chief cause of poor results in the past particularly after the first World War was surgery done in the presence of or too soon after infection and sepsis. Many of the stumps broke down, became infected or were otherwise unsatisfactory because of improper selection of cases and timing of the operation. Even the severest critics of the Syme amputation have admitted that these factors have in the main been responsible for the failures and unsatisfactory results in the past. Experience in the war recently ended has conclusively shown that these causes of failure can be eliminated and that good results can be obtained even on the war injured.

In the clean or civilian cases on the other hand satisfactory stumps capable of good function for many years or as long as the patients live have generally been obtained. This helps to explain why there has been such a difference of opinion about the merits of the Syme amputation among the leading surgeons of the same country in the same generation. Wheeler in England for instance says that he has followed patients operated upon by his seniors up to fifty years previously and in advanced years the stumps were still good. The patients had led long and useful lives being little handicapped by the amputation.

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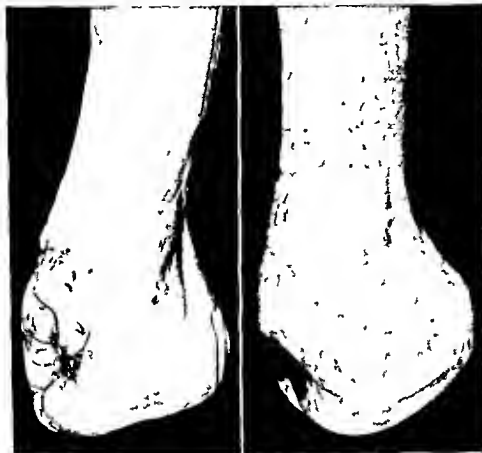


Fig 214—Types of war amputations on which the Syme is most frequently performed

tion Many other cases have been reported in which the stumps held up well for forty or more years and throughout life This is the more remarkable since the operations were done before modern asepsis

came into being. Wheeler is emphatic in stating that, 'In many cases which failed in the last war the operation was either contraindicated or performed under adverse conditions.' 'Furthermore,' he states 'a proportion would have been a success if a good prosthesis had been provided.' Philip D. Wilson in 1921⁴ called attention to the great advantages of the Syme amputation and described the operative technic and after-care. Canadian surgeons have repeatedly advocated this amputation and have followed their cases, done in World War I, up to the present time. They still advocate it strongly.

ADVANTAGES

The Syme amputation as compared to the below-the-knee amputation is more conservative, leaving the patient more of his anatomy for which he is truly appreciative. It is the best major amputation in the lower extremity in that there is full length of the leg to the ankle.

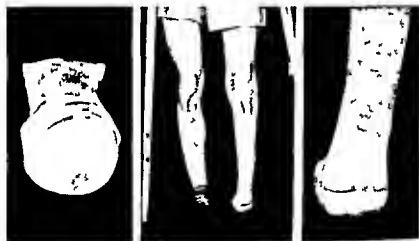


Fig. 215—A typical Syme stump

for leverage, and it is capable of full end bearing with or without a prosthesis. Patients—even double Syme amputees—can walk on the bare stump ends inside the house, about the bedroom and bathroom, which is a tremendous advantage. In the case of double lower limb amputations, double Syme amputees are hardly incapacitated as compared with the double below-the-knee amputees. They not only walk better but, as a result of the longer stumps, better leverage and full end-bearing with no apparatus above either knee, they can stand and walk about normally. Even one Syme together with a below or above-knee amputation of the other leg is a great advantage, particularly since the patient depends on the Syme stump for standing and has one leg free of apparatus above the knee. We have had two double

Syme amputees and six who had a Syme amputation on one side and an above the knee or a below-the-knee amputation on the other. After carefully studying these patients, one is convinced that the Syme amputation has its greatest advantages in these cases. Single Syme amputees are not handicapped or incapacitated, they are merely inconvenienced. They can do most of the things they want to do or that anyone can do.

One of the greatest advantages of the Syme amputation is the ease with which it can be fitted with a limb as compared with the below-knee amputation. The prosthesis in the former is bootlike, with no



Fig. 216—A, X-ray appearance of the Syme stump. B, Method of wrapping the Syme stump with elastic bandages for shaping and shrinking the stump.

apparatus extending above the knee as in the latter. In our experience, with the Syme the fitting of the prosthesis is easy as compared with the below knee amputation. Once fitted the patient does not have the difficulties or need the changes and adjustments that the average below knee amputee must have. Syme amputees do not object in the least to the bulbous appearance of the prosthesis at the ankle when they find out for themselves by living with below the knee amputees how much more fortunate they are functionally.

The Syme amputation has definite advantages over many partial foot amputations. It is simpler to fit with a prosthesis, and the patients walk and run better and do not tire as easily. However, we have been

very conservative about substituting the Syme for the partial foot amputation if the patient has enough of the foot left to walk with a good gait wants to keep it the tendons are intact there is no deformity the stump is painless covered with good skin and there is good circulation A partial foot amputee under these circumstances can be supplied with a filler in the shoe and a steel shank and get along very well without the stigma that goes with a major amputation which requires the use of an artificial limb The Syme amputation is preferable in every respect to any partial foot amputation which cannot by surgery or prosthetic appliance be made to meet the requirements of reasonably good lower limb function Unfortunately no iron clad rules can be laid down for the length of a partial foot stump which can be said to be functional It varies depending on many individual factors The judgment of the surgeon has to be applied therefore to the individual case in question

The Syme amputation is preferable to the Pirogoff because the results are more certain The result in the Pirogoff is dependent upon the osteoplastic procedure of approximating part of the os calcis to the end of the tibia If bony union fails to develop the result is jeopardized A more serious objection to the Pirogoff amputation is that the stump is too long for fitting with an ankle joint without difficulty

DISADVANTAGES

There are no functional or anatomical disadvantages as amputations go to a good Syme stump singly or combined with amputation at any level of the opposite limb The chief objection to the Syme stump is purely aesthetic For this reason the Syme operation should rarely if ever be done on a woman Fortunately injuries requiring amputations in women are comparatively rare and because women are less vigorous the Syme procedure is not as necessary in them as in men Another disadvantage of the Syme amputation lies in the additional skill and judgment required on the part of the surgeon for good results To be justified the end result of the Syme must be good—that is capable of full end bearing and free from tenderness and pain To get this result requires better judgment in the selection of cases for operation and more meticulous attention to the details of the operative technic and after care than probably any other amputation However the necessary requirements can be met by any good surgeon without too much difficulty The surgeon must be convinced that the Syme is the best amputation and he must be able and willing to carry out the proper operative technic and to personally carry out the post operative care of the stump until the patient is finally fitted satisfactorily with a prosthesis

INDICATIONS

Since the Syme amputation is not only the most conservative anatomically, but the best of all major lower limb amputations functionally it is clearly preferable to all others at any higher level and to many partial foot amputations. It has had its greatest field of usefulness in young men following war injuries where so much of the foot has been lost that the remaining foot stump is too short for good function. Since most war amputations are left open or should be most of the foot stumps suitable for conversion into the Syme are contaminated badly or infected at some stage between the open am



Fig 217—Three different types of temporary pylons which may be applied as early as three weeks postoperatively. These are particularly useful in shrinking and toughening the stump before the mold for the permanent prosthesis is made. Skin tight plaster is preferable and is used for about four weeks.

putation and the final Syme procedure. Cases of this type must be handled extremely carefully or the results of the Syme amputation will be disappointing to the surgeon and the patient. The open stumps should be clinically and bacteriologically clean before the Syme operation is performed. Swelling or edema should also be at a minimum. It is not always necessary but it is usually desirable for the wound to be completely healed. If spontaneous healing of the foot stump is too slow, it may be hastened by a preliminary split skin graft if it is not clean. Cleanliness of the foot stump preoperatively is one of the most important of all considerations. Complete bed rest with elevation of

the foot has never had a satisfactory substitute in the preoperative stage. Penicillin is used routinely preoperatively and postoperatively in all cases in which there has been sepsis, regardless of how clean

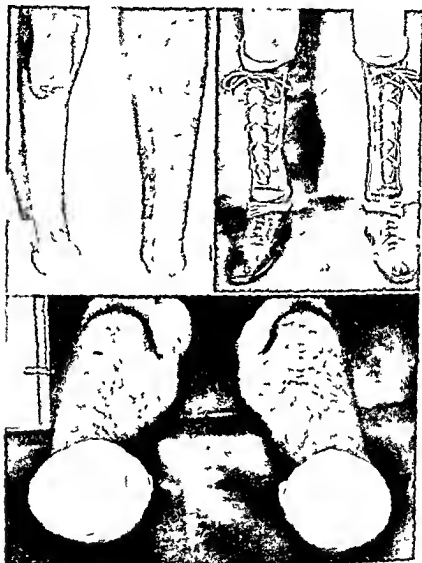


Fig. 218.—End result of a double Syme amputation. Both amputations were performed at the same sitting and the patient is able to stand and walk on the completely bare stump ends.

they seem to be at the time of operation. This prevents a waiting period from the time of wound healing until final surgery is done and assures against activation of latent infection.

Some war wounded have had ligation of the femoral, popliteal or

tibial vessels in addition to the injury which resulted in loss of the forefoot. In these cases, even in the complete absence of pulsations at the ankle, the Syme amputation can be done and the bleeding is as profuse at operation and the wound healing as good as in non-ligation cases, if lumbar sympathectomy is done preoperatively. We have had two such cases, one of which had ligation of the femoral vessels in the middle third of the thigh, and the other had ligation of the popliteal vessels.

The war wounded may also have in addition to the forefoot amputation, severe compound fractures of the upper third of the tibia and fibula with resulting osteomyelitis and sequestration. Still others have extensive loss of skin and soft tissue around the upper third of the leg below the knee with scar or skin graft. In either case, when the foot of the same leg has been amputated so short that it is useless for weight bearing, the surgeon has to make the choice between a Syme or an above the knee amputation. In these cases it is far more conservative to treat the soft tissue and bone injury as though the foot had not been lost and later do a Syme amputation, than it would be to amputate above the knee. We have had a patient with a Syme amputation representing each of the above combined types of injuries. They are both happy with good functioning Syme stumps as a final result. In this type of case, below the knee amputation is out of the question because of the scarred condition of the stump or the presence of skin grafts which will not stand the trauma of wearing the prosthesis.

The Syme amputation can be successfully performed after many partial foot amputations in which there are also severe fractures of the os calcis, astragalus and lower ends of the tibia and fibula. In the case of the last, the fractures should be allowed to solidify before the operation is done. The above additional conditions are not rare in war injuries, as we have had four such cases in the past year, in which the Syme amputation has been successfully performed.

The question naturally arises as to how much of the heel is needed to permit use of the Syme technic. All possible length should be saved at the time of the original open amputation of the foot, but it is possible to get a good Syme with as little as 1 inch of the heel left. After these short partial foot amputations, particularly where only the heel or part of the heel is left, the balance of the foot tends strongly to become fixed in equinus. No attempt should be made to prevent this, on the contrary, it should be allowed to take place as it is a distinct advantage in many cases since the redundant skin posteriorly over the ankle becomes shortened and shrunk before the Syme amputation is done and thus does not have to be accomplished afterward. The skin of the heel should be good, free from too extensive scars, and have good circulation and sensation.

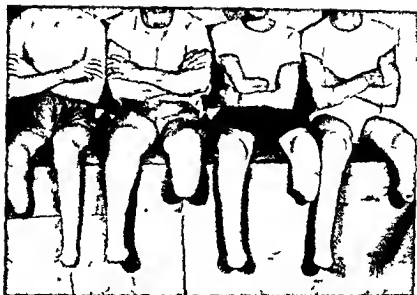


Fig 219—Upper, These patients illustrate the great advantage of having one Syme where possible in combination with an amputation of the opposite extremity. Lower, Illustrates the advantage of the prosthesis for the Syme amputation over that for the below the knee amputation.

It must be remembered that, to be justified, a Syme stump must be good, i.e., painless, have good circulation, sensation, and above all, it should be capable of full end weight bearing. If for any reason the Syme stump falls short of these requirements, it is a failure and the patient would be better off with a below-the-knee stump. For these reasons it is best not to do so-called "tricky Symes," using skin for the stump end from areas other than the weight-bearing surface of the foot. The best rule to follow is to do a below the knee amputation if there is any doubt as to whether the Syme amputation is clearly indicated.

This amputation has been done for a number of nontraumatic conditions. Many cases have been reported in the older literature in which it was performed for tuberculosis of the ankle joint and the tarsus—sometimes apparently with success. It has also been performed for malignant and benign bone tumors and for intractable club foot. More conservative or different orthopedic procedures are usually carried out now for these conditions.

CONTRAINDICATIONS

The Syme amputation should never be performed as a primary procedure following war injuries. We have seen two so-called Symes done under such circumstances which resulted in poor stumps. The operation is never justified in the presence of nearby unclean wounds. Peripheral vascular diseases, such as thromboangitis obliterans and arteriosclerosis with or without diabetes, are clear cut contraindications for this amputation. Total loss of sensation due to irreparable peripheral nerve lesions represents another condition in which the Syme amputation should not be done.

Gangrene of the forefoot due to frostbite, trench foot, freezing, or combinations of these, does not constitute a clear-cut contraindication. These conditions frequently result in loss of the skin over the heel making the Syme amputation impossible. Persistent tenderness in the adjoining viable tissues associated with gangrene from these causes is a contraindication to this amputation only when the tenderness extends into the soft tissue which will be retained as part of the Syme stump. Here again we have been able to perform the Syme amputation successfully in a number of carefully selected cases of this type.

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THE DIAGNOSIS OF PERIPHERAL NERVE LESIONS

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It has been estimated by various observers that some injury to the peripheral nervous system occurs in 10 to 20 per cent of all battle casualties. It is not surprising that a freshening of interest in the study of peripheral nerve injuries should occur with every major conflict. During the first World War, a great deal of work was done and for the first time a hopeful attitude toward the repair of peripheral nerves was developed. However, in spite of the large number of reports from this country, England, France and Germany on the results of peripheral nerve surgery, it is difficult to evaluate these results. Reference to the reports of Naffziger, Stopford, Davis, Delageniere, Foerster and others brings to light the great disparity that existed in the reported results of nerve repair, and it is obvious that this apparent difference is due largely to the lack of standard criteria for determining the degree of recovery. One is left with the choice of accepting or not accepting the opinion of the surgeon that his patient was cured or improved, and while considerable emphasis was placed on preoperative clinical examination, there is little evidence except in a few instances that precise records were kept following nerve repair. Moreover, recovery of movement was often accepted as indicating reinnervation of formerly paralyzed muscles without recognizing the importance of substitution.

The phenomenon of substitution is an important one. The degree to which it can be developed depends on the availability of muscles having a similar function to those that are paralyzed and the facility with which the patient reeducates himself. The hand is a frequent site of effective substitution. In case of a low median nerve paralysis the ability to oppose the little finger and thumb is usually reacquired through education of the ulnar supplied muscles of the thenar eminence. In the case of a wrist drop due to radial nerve paralysis, the patient may learn to maintain his wrist in extension by forcibly flexing the fourth and fifth fingers thereby leaving the thumb, index and third fingers free to carry out purposive movement. Another excellent example of substitution occurs in paralysis of the circumflex nerve to the deltoid muscle. Normal abduction of the arm is lost, but the patient soon learns that he may initiate the movement with the supra

The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Naval Department or the Naval Service at large.

spinatus muscle. Then, by fixation of the humero scapular joint with other shoulder muscles, the entire shoulder girdle may be elevated and inwardly rotated by the trapezius which will effectively abduct the arm to the horizontal position. These physiological tricks may mislead the inexperienced observer into thinking that some return of function has taken place in the paralyzed muscles.

Sensory examination is less apt to be confusing, however, the examiner is dependent upon the subjective responses of the patient and it is sometimes difficult to distinguish between an organic loss of sensation and an hysterical one. In lesions of nerves to the hands and feet

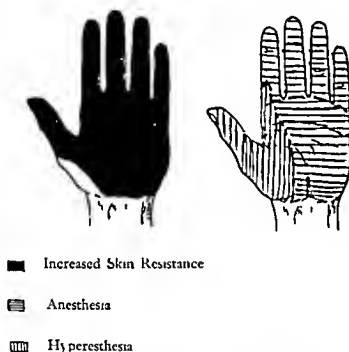


Fig 270—Case with partial median and complete ulnar paralysis with sensation returning to median distribution before vasomotor recovery

there is usually considerable vasomotor disturbance manifested by loss of sweating in the involved areas with trophic changes and wasting of the fat pads of the finger tips.

In the interim between the two great wars, much progress was made in the development and perfection of electrodiagnostic equipment and, at the present time, it is possible to determine with great accuracy whether any given muscle bundle is denervated partially or completely. By repetitive tests it is also frequently possible to prognosticate reinnervation or further deterioration. Interference to or loss of the vasomotor nerve supply to any area may be accurately plotted by determination of skin resistance using a simple ohmmeter. How-

ever, it should be noted that vasomotor distribution does not coincide with the somatic sensory distribution and that estimation of vasomotor status by means of special procedures such as the determination of skin resistance cannot be used as a basis for assuming the sensory status to be the same (Fig 220)

During the recent war, centers for the study of peripheral nerve lesions were set up in this and other countries. It is the purpose of this communication to describe the diagnostic procedures currently used, the method of recording data and a standard for evaluating results

HISTORY

Each case study should begin with a record of the injury and an attempt to classify the *mechanism of its production*. This is of considerable importance, as the nature and extent of the lesion is dependent upon the character of the inflicting agents. For example penetrat

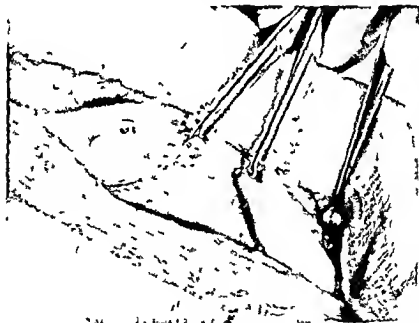


Fig 221—Severance of sciatic nerve without damage to adjacent tissues

ing wounds such as simple stab wounds are most apt to produce clean-cut nerve severance without damage to the nerve away from the point of section (Fig 221), wounds by shell fragments cause ragged laceration of nerve trunks frequently carrying the distal end far from its normal position with gross destruction of surrounding tissue which of necessity leads to dense secondary scarring (Fig 222), through and through wounds by high velocity missiles may produce extensive

damage to nerve trunks without actually coming in contact with them. This latter type of injury is classified as nerve concussion and is caused by the short lived but violent contortion waves in the soft tissue attendant upon the impact and passage of a small but rapidly moving missile.

There are also injuries to the neurovascular bundles in which the anatomic continuity of the nerve trunk itself is not disturbed but the escape of blood from an injured vessel into the fascial plains between the nerve trunks incites secondary fibrosis and the formation of dense keloid like encasements of the nerve trunks (Fig. 223). Nerves may



Fig. 222—Shell fragment wound of popliteal space with widespread destruction and displacement of structures. 1, Tibial nerve. 2, Distal end of peroneal nerve. 3, Central end of peroneal nerve.

be secondarily injured in association with fractures of contiguous bones, in these cases, the nerve injury may vary from actual severance to simple involvement of the uninjured nerve by callus formations. A less common form of nerve injury occurs with stretching of the nerve. The most frequent site for this type of injury is the brachial plexus where it is caused by violence to the shoulder girdle. In extreme cases one or more spinal roots may be completely avulsed from the cord. Permanent damage to a nerve may also occur with stretching and is due to minute ruptures of perineurium and secondary herniations of nerve bundles. This may result in the formation of multiple minute neuromas throughout the nerve trunk. In milder degrees

of stretch with axonal damage only complete regeneration usually occurs

Interval or lapse of time between injury and repair is of considerable importance because of a series of events that takes place following interruption of neuronal continuity. Denervation of a muscle leads at first to loss of tone then to atrophy wasting and finally fibrosis of the denervated muscle. The rapidity with which these changes occur varies considerably in different muscles. The reason for this variation is not understood but the writer has observed that muscles that have to do with antigravity tonus show the most rapid and extreme atrophy. In addition to the changes in the muscles changes also occur



Fig. 223 Keloid like encasement of nerve partially dissected

in the distal end of the severed nerve. Shrinkage of the Schwannian tubes and increase in the intraneural fibrous tissue may so confine the regenerating axones that they cannot mature and thus will not conduct impulses at the normal threshold. If for any reason such as associated fracture or infection the extremity is immobilized for long periods during this interval or if there is an associated vascular lesion along with the nerve palsy fixation of the joints is apt to occur and in addition to the above mentioned atrophic changes the affected mechanism may be so deformed that no recovery of function is possible even after nerve regeneration.

The patient is likely to have received some form of definite treatment prior to his arrival at a Neurosurgical Center. A primary at

tempt to repair the nerve may have been made at the time of injury or he may have been secondarily operated upon at an advanced base hospital. In either case, it must be borne in mind that such procedures were carried out under difficult circumstances and the operator may not have been one experienced in the repair of nerves. Even when apparently adequate records of the surgical treatment are available such records are not necessarily reliable. It is not infrequently found in a case in which a classical nerve repair has been described, that actually tendon has been sutured to nerve. Prolonged infection of the wound site with secondary scarring adversely affects the prognosis. It not only makes secondary operation more difficult but also, in such cases, there is proliferation of endoneural fibrous tissue necessitating wider resection of the nerve stumps. This loss of nerve substance is not of so much importance in the midportion of a nerve trunk (example the ulnar at the elbow joint) as it is at the periphery or near the spinal cord. In both the latter locations, a loss of nerve substance results in faulty orientation in opposing the cut surfaces and, secondarily, in distributional confusion.

CLINICAL EXAMINATION

Upon examination of the patient, careful note must be taken of associated factors such as loss of substance of soft tissue, bony deformity, fixation of joints, skin scarring and circulatory disturbance. The gross state of the motor apparatus should be evaluated.

In isolated nerve palsies, there is usually a characteristic postural deformity which is the result of the action of unopposed normally acting muscles. These postural deformities do not occur as a rule in partial paralysis, and it is interesting to note that in recovery after nerve repair, the postural deformity may disappear long before there is visible voluntary movement in the affected musculature. This leads to the supposition that impulses for the maintenance of tonus may function at a lower amplitude than purposeful voluntary impulses. By having the patient carry out special movements, it is usually possible to detect loss of function of muscle groups and in some instances of specific muscles. Even though the examiner is very familiar with the normal anatomy and the common anatomical variations it is well to refer frequently to charts which show the levels at which the various branches leave the main trunk (Fig 224).

Sensory examination should be carried out routinely for light touch and pain. There is little evidence that additional value is obtained by examination for position sense, temperature or other modalities. However, in examining a patient following nerve repair where distributional confusion may be an important factor, the recovery of pain and touch sense is by no means an indication of satisfactory sensory recovery. Here the patient must be tested for his ability to locate

the stimulus and to determine two point sensibility by careful comparison with a corresponding area in the unaffected extremity

Tinel's sign is valuable in determining whether or not the nerve has been completely severed, and may be an indication of reaxonization. It is elicited by lightly tapping along the course of a nerve trunk. If at any point the patient experiences a tingling sensation referred to the distribution of the nerve, one may assume that unmyelinated regenerating sensory axones are present.

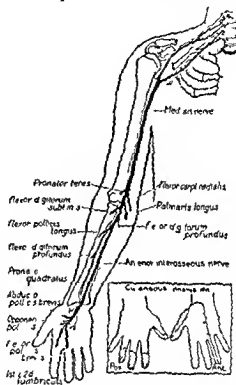


Fig. 224—Example of type of chart to be used for reference in giving clinical examination. This is a diagram of the course and distribution of the median nerve. (After Woodhall and Haymaker.)

ELECTRICAL STUDIES

No matter how careful or experienced the observer, the above mentioned clinical studies must be augmented by special tests in order to establish the status of the neuromuscular mechanism. Various types of electrodiagnostic procedures have been devised. Much is still unknown regarding the underlying physiological mechanism upon which these tests are based. This however does not detract from their value as clinical tests. Special studies are also of value in studying the sensory apparatus, but because of the adequacy of clinical sensory examination are of considerably less importance.

In general, it may be stated that a muscle fiber, when deprived of its nerve supply, may be stimulated directly, that a muscle fiber's response to stimulation is different in form and degree from that elicited by stimulation through its normal nerve supply, and that, during a period of reinnervation or denervation, variations in the response may be recognized and used for gauging the extent of the process under study.

Various types of currents are used for the electrical study of nerve muscle mechanisms. It may be said that a current is either biphasic or monophasic. Examples of these types are:

Farad Current This is obtained from an induction coil and consists of a series of rapid short biphasic impulses. It will induce contraction in the normal muscle, but does not as a rule produce any

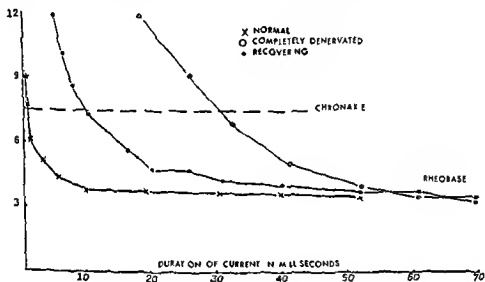


Fig 225 -Examples of strength duration curves

response in a completely denervated muscle. It has little value in electrodiagnosis.

Alternating Current of the type supplied by public utility systems. This is a biphasic current of a fixed cycle. It is also limited in its application to electrodiagnosis, but is of value where a continuing stimulus of known strength is needed. Apparatuses have been designed to produce a current of this type permitting variation not only in the strength of the current but also in the rapidity of the phase reversal. This type of current is valuable in the experimental stimulation of the cortex, but is less commonly used in peripheral nerve study than the type to be described.

Galvanic or Direct Current This is a constant monophasic electrical current which flows steadily from a positive to a negative pole. It is capable of producing a contraction in muscle either through its

nerve supply, or in the case of a denervated muscle, by stimulation of the muscle directly. The amount of current and the duration of flow necessary to produce a contraction will vary greatly in the two instances. Most of the modern diagnostic tests are based upon this phenomenon.

It is not practical to measure the force or the amount of muscle response to a given stimulus, instead, one determines the amount of current necessary to produce a certain minimal response in the muscle. The term *rheobase* has been devised and may be defined as the minimum amount of current of unlimited duration necessary to induce the smallest visible contraction of a muscle.

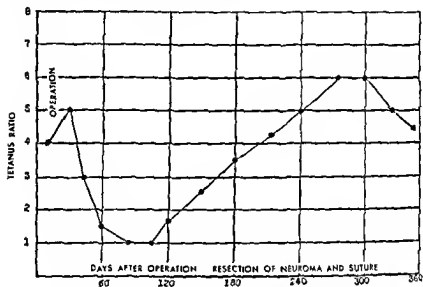


Fig. 226—Galvanic tetanus ratio computed by dividing rheobase into milliamperage necessary to produce tetanus (After Pollock)

It has been found that by increasing the amount of current, the duration of the current necessary to produce this smallest visible contraction will vary inversely as the current is increased and it is possible for any given muscle to plot a curve, known as the *Strength Duration Curve*. The ordinates represent the amount of current and the abscissae the duration. It is possible to determine from the position and form of this curve whether a muscle is partly or completely denervated (Fig. 225).

It will be seen from a study of these strength duration curves that for any given current a longer duration of flow will be necessary to produce a contraction in the denervated muscle than in the normal. It has been practical to select one point arbitrarily, namely, a current of twice the rheobase. By using this current and determining the dura-

tion of flow necessary to produce a contraction, a value is obtained which will differ greatly between the normal and denervated muscles. The duration of flow of a current of twice the rheobase necessary to produce the smallest visible contraction in a muscle has been termed *Chronaxie*. In the S D (strength duration) graph the chronaxie values are seen to be normal 0.9, recovery 10, denervated 31 milliseconds.

In a normally innervated muscle stimulation with a galvanic current will induce a contraction in the muscle on the make and break of the current. If the current is increased considerably the muscle will remain in tetanic contraction throughout the duration of the current. The ratio between the amount of current necessary to produce the minimal visible contraction and that necessary to produce a tetanic contraction is known as the *Stimulus Tetanus Ratio*. It has been found that this ratio will vary enormously between the normal and denervated muscle. It is seen from the accompanying graph that the normal stimulus tetanus ratio is approximately 4 or 5 to 1, and that immediately following nerve section that is during the period of denervation, the ratio increases sharply then falls so that the ratio for a totally denervated muscle approaches unity. During reinnervation the value again increases and only returns to normal a considerable time after return of function has occurred (Fig. 226).

In all the above described procedures using galvanic current the cathode or negative pole is used as the active electrode, that is the electrode placed on the muscle to be tested. Also the muscle response referred to is that obtained on initiating the passage of current. If the current used is of sufficient amplitude a contraction will also occur on cessation or break of the current. By reversing the direction of the current the indifferent electrode becomes the cathode and the active the anode. The responses to the passage of current is different in two instances. This has been expressed in *Pfluger's law* as follows:

Cathode closing contraction is greater than Anode closing contraction

Anode opening contraction is greater than Cathode opening contraction

At one time much importance was attached to the observation that in denervated muscles these relationships were reversed and the so called reaction of degeneration was present when ACC greater than CCC and COC greater than AOC. This concept was formulated at a time when it was thought that a current flowed from the anode to the cathode. We know now that negatively charged ions are discharged from the cathode and pass through the tissues to the anode. These ions in sufficient concentration are capable of initiating muscle contraction. There is therefore no such thing as an anodal stimulus and the entire concept is subject to criticism. The difference in response on reversing the current is due to the fact that in the normal muscle a concentration of ions at the intact motor end point produces a stimulus which is transmitted to the entire muscle. This is more apt to occur when the cathode is used as the active electrode. However, this finding is not constant.

Of the various tests described the writer has found chronaxie to be the most valuable in clinical application. The chronaxie of all of the muscles supplied by a nerve may be determined in about the same length of time it takes to plot the strength duration curve for

a single muscle. To test only one muscle in a nerve supply may lead to erroneous conclusions. A single determination of stimulus tetanus ratio is not of much value and can only be interpreted in relationship to previous and subsequent determinations. Also chronaxie determination is much the least discomforting to the patient and this is of some consideration when one expects to repeat the tests at frequent intervals.

In evaluating results of peripheral nerve surgery all the factors enumerated above must be taken into consideration and it has been found convenient to use the form shown below for recording the data in each case.

Name	Nerve Injured		Date									
			Interval									
Interval Treatment	Plasma Repair		Date									
Pre Op Studies	Chronaxie	EMG	Skin Resistance									
<hr/>												
Operation Notes												
Condition of Nerve Ends												
Length of Gap		Condition of Nerve Bed										
Extent of Lesion (at operation)												
Tension		Angulation of Joint Fixation										
<hr/>												
Post Op Record												
Chronaxie												
Other Tests												
Skin Resistance												
Clinical Signs												
Months	1	2	3	4	6	8	10	12	16	18	20	24
Evidence of Return												
Degree of Recovery												
Disposition												

When the patient has reached the point of maximum improvement the result must be graded according to readily understood criteria. The motor and sensory improvements are rated separately according to the following scales.

Motor

- 0 No contraction
 - 1 Flicker or trace of contraction or drop in chronaxie
 - 2 Active movement with gravity eliminated
 - 3 Active movement against gravity
 - 4 Active movement against gravity and resistance
 - 5 Normal power and all muscle reinnervated by chronaxie test
- (This is a slight modification of the Oxford Scale)

Sensory

- 1 Return of deep pressure sense often with distributional confusion
 - 2 Touch and/or pain sense
 - 3 Distinction of sharp and dull
 - 4 Localization of touch
 - 5 Two point sensibility and stereognosis
- (The presence of hyperesthesia or distributional confusion drops the rating by one)

CALCULUS FORMATION IN THE BEDREST PATIENT

MAJOR GEORGE C. TULLY AND MAJOR LLOYD E. HAWES

MEDICAL CORPS ARMY OF THE UNITED STATES

It has been known for a long time that renal calculi may form during prolonged bed rest, and isolated instances have been reported. However the incidence of stone formation has been emphasized when large numbers of bedrest patients have been grouped together as orthopedic casualties in large Army general hospitals. These patients have had renal calculus formation as a complication of their care in bed and most of them have had acute abdominal symptoms or a typical renal colic while still in bed in spica or traction. Attention has been called to these patients by the acute symptoms. Relief of the symptoms has been rapid when the correct diagnosis has been made.

In a period of one year there have been thirty two cases of stone formation in orthopedic patients on prolonged bed rest at a large Army general hospital. In all but one a true calculus was recovered or seen in the roentgenogram. These cases represent about 0.6 per cent of all the orthopedic patients treated in that year. All of these patients had no infection of their urinary system, no renal anomaly or other abnormality of the urinary tract and no history of calculi or other renal disease. Over one half of these cases have been followed for several months or until the patients were discharged from this hospital completely recovered from their orthopedic disability. All diagnoses have been confirmed by plain roentgenograms and emergency intra-venous pyelograms.

All of the stones have been composed of calcium and all but one was primarily calcium phosphate. In the remaining case the formation was primarily calcium carbonate.

At the time of the acute symptoms the patients had been in bed for as short a time as five weeks and as long a time as thirty three weeks.

In the same year two patients with wounds of one ureter developed renal calculi while at bed rest and interestingly in their undamaged and freely draining kidney. The stones formed in the kidney that could put out urine and not in the kidney with impaired function. One patient with multiple vesicocutaneous fistulas following a gunshot wound developed bilateral fine calculi. There were two other bedrest patients who developed calculi, one with extensive actinomycosis of the soft tissues of the pelvis and one with severe ulcerative colitis.

From the Genitourinary and X Ray Sections, Rhoads General Hospital, U. S. A., New York.

DIAGNOSIS

The patients displayed three different kinds of symptoms (1) acute abdominal symptoms highly suggestive of appendicitis, (2) typical renal colic, and (3) the passage of a stone in the voided urine without prodromal symptoms

The first group, representing 32 per cent of the cases from the orthopedic service, presented with their acute symptoms a nice differential problem between acute appendicitis, renal colic and an acute gastroenteritis. The first case is typical of this group

CASE 1—In August, 1944, a 22 year old soldier received a large wound in the upper left thigh from an 88 mm shell. This resulted in a compound fracture of the upper femur. The leg was placed in a cast. In a few days the cast was removed because of poor alignment, and traction applied. Six weeks after injury, in October, 1944, a full body spica was applied and the patient transported back to the United States. On admission to this hospital there was no evidence of infection, and upon removal of the cast the soft tissues were well healed. He was placed in a Thomas splint.

Sixteen weeks after the original injury, in the first week of December, 1944 the patient began to have epigastric pain which gradually increased in intensity. The pain radiated to the right lower quadrant. Two hours later he became nauseated and vomited once. There was no rise in temperature, the white count was 7600. Palpation of the abdomen revealed no localized tenderness. A routine urine specimen showed *innumerable red blood cells*.

Roentgenograms of the abdomen showed two 3 mm stones in the right kidney. Immediate intravenous pyelography revealed dilatation of the right ureter and pelvis. Cystoscopy was performed, and a small calculus was removed from the right ureteral meatus. The symptoms were immediately relieved. The patient had no subsequent abdominal symptoms. There was no further hematuria. Upon his discharge six months later, an abdominal roentgenogram showed complete disappearance of the renal calculi.

Perusal of his previous laboratory reports showed that there had been 6 to 8 red blood cells per high power field in his urine two weeks *before* the onset of symptoms.

Patients in this group usually had a gradual onset of abdominal discomfort which later turned to pain. The pain was steady and not colicky. Nausea was very frequent. Vomiting was sometimes recurrent, and in one patient was the chief complaint. There were no urinary symptoms. The picture suggested appendicitis. In no case was the white count over 11,000, and there was no increase in the ratio of polymorphonuclear leukocytes. There was often a slight rise in temperature, but none went over 101° F orally. One patient had a chill. In three patients the pain gradually settled in one loin or groin, and some tenderness could be detected over one kidney or ureter.

The symptoms in this group were entirely gastrointestinal: nausea, vomiting, and epigastric or midabdominal pain. Urinary symptoms were not present to aid in diagnosis. The urine was examined early—its examination should always be the first procedure in these patients. Examination of the urine is easy, rapid, and of the utmost diagnostic

importance. It should be done concurrently with the white blood count.

In all cases a flat abdominal roentgenogram was obtained which was followed by an intravenous pyelogram as an emergency procedure. A prolonged preparation for the pyelogram was unnecessary and delayed diagnosis. In these cases one is looking for renal block as shown by nonfunction of one side, increasing density of one kidney without dye appearing in the pelvis, or dilatation of pelvis and ureter above the point of obstruction.

These roentgenological findings were seen in all of the bedrest patients complaining of acute abdominal symptoms and having hematuria. We have not found a gas and feces filled colon or gas in the small bowel to hinder the discovery of partial or complete ureteral block. We have not found dehydration, which requires hours of delay, necessary for an adequate concentration of dye.

Rarely, hematuria may not be found and no stone may be revealed in the roentgenogram, when a bedrest patient presents his physician with acute abdominal symptoms. The physician should not be misled by this, but should immediately perform emergency pyelography. At the time of symptoms the patient's urine may be clear, whereas previously or subsequently red blood cells will be present in the urine. The following case will illustrate the need for the entire trial of diagnostic procedures in each case.

CASE II—A 50 year old man broke his left hip in August 1944. Subsequent to nailing an abscess developed around the left hip which required incision, penicillin and fixation in a spica. The spica remained for two months. As he first began to sit up in a wheel chair thirty one weeks after the original injury which put him to the lower started an subsided.

flat roentgenogram showed no calculi. On the following day there was right costovertebral tenderness and a pyelogram revealed a right hydronephrosis. Cystoscopy showed no spurt from the right orifice until after ureteral catheterization. Then a spurt of muddy debris filled urine came from the ureter around the catheter. The ureteral urine contained an occasional white and an occasional red cell. Its culture gave no growth. There were no subsequent attacks.

In this patient the urine at the time of his symptoms was free from red blood cells, and the abdominal roentgenogram showed no stone. The pyelogram was therefore delayed twenty four hours. When it was obtained the cause of the symptoms was found to be a block of the right ureter. In all bedrest patients with symptoms all three steps should be carried out.

The second group of patients, 55 per cent, had typical renal colic which made diagnosis easy.

The third group of patients, 13 per cent in all, noted a stone in their urine as they voided as the first indication of renal calculus formation. These patients all had microscopic hematuria and many had additional stones demonstrable by roentgenogram.

Some of the bedrest orthopedic patients were found to have a microscopic hematuria in their "routine" specimens obtained after admission. They had had no symptoms. Flat abdominal roentgenogram showed renal or ureteral calculi. The presence of hematuria in the urine of any bedrest patient is very important, and when detected a plain roentgenogram and intravenous pyelogram must be obtained.

ROENTGENOGRAPHIC FINDINGS

Stones when present were divided as to location and number as follows:

	Per Cent
Unilateral stones	73
Bilateral stones ..	27
Renal stones	40
Ureteral stones	33
Renal and ureteral stones ..	27
Solitary stone	20
Multiple stones	80

It can be seen that the stones were usually multiple and scattered about in the kidneys. It is difficult to understand why the stones were so frequently unilateral. Often fine calcareous material and tiny rounded calculi outlined the calices, infundibula, and even the pelvis quite completely. A calcareous cloud would entirely outline one or more calices. In one case, fine calcareous material extended down into the ureter.

Pyelography, as mentioned above, revealed in all patients with symptoms some degree of ureteral block. There was no x-ray evidence of pyelonephritis or renal anomaly.

CALCULUS FORMATION FOLLOWING GUNSHOT WOUNDS TO THE GENITO-URINARY SYSTEM

In patients who have had gunshot wounds to the genito-urinary system and have been in bed for several weeks, calculi have developed. We have seen three such patients. One had a stricture in the lower left ureter with a moderate hydronephrosis above, and impairment of function of the left kidney. Another had a complete left ureteral transection with a cutaneous fistula. In both, stones formed on the unaffected, uninjured side and no stone formed on the injured side. Urine from the unaffected side was sterile, and free from white blood cells. The third case had numerous vesicocutaneous fistulas; fine stones filled both sides but were unaccompanied by hydronephrosis or impaired function.

It is important for the surgeon to recognize the possibility of stone formation in these patients, and to look carefully at the good uninjured side before any operative procedure on the involved kidney and ureter.

CALCULUS FORMATION IN OTHER NONORTHOPEDIC PATIENTS

These have been reported in the literature in patients on prolonged bed rest from other causes than the above. We have had at this hospital two such patients. One had an extensive *Actinomyces* infection of the soft tissues of the pelvis, and could not move about in bed because of great pain. He was moved passively as much as he would tolerate. Accidentally, on one film of the pelvis the lower poles of the kidney were included, and both calices, pelves and upper ureters were seen to be packed with tiny stones and calcareous material. The patient had no urinary symptoms or infection. The other patient had severe ulcerative colitis and had been in bed for several weeks. The stones were asymptomatic.

CAUSE

It has long been known that decalcification takes place in the bones of any part immobilized by cast or not used, as in muscle paralysis or a painful extremity.

It is well known that the excretion of calcium in the urine increases in patients with fractures who are confined to bed. However it has recently been proved that a healthy male, confined in a spica for several weeks also goes into negative calcium balance. Large amounts of calcium are excreted in the urine. It is evident that the presence of a fracture is not necessary for increased calcium excretion in a person confined to bed.

Neither infection nor stasis is necessary for stone formation in the bedrest patient, though we realize that they are in many instances important factors in the formation of stones. No urinary infection was found in the orthopedic cases in this series. In the two patients with ureteral injury, infection and stasis were present on the injured side. No stones formed on this side. The stones appeared on the freely draining, uninfected side.

Why one patient on bed rest forms stones, and another patient on bed rest does not, is unknown.

PROGNOSIS

All patients with complete or partial block required cystoscopic manipulation. The usual well recognized procedures were used in the management of these patients: i.e. indwelling ureteral catheter, ureteral meatotomy, manipulative removal by basket, and so forth. No ureterolithotomy was necessary in this group. One patient with stricture of the left lower ureter following gunshot wound required a pyelolithotomy on the normal right side for the removal of a large triangular pelvic calculus.

No further operative treatment was necessary after the removal of the blocking calculus though numerous small calculi remained in one or both kidneys.

Fifteen cases have been carefully followed to date, and the patients have been discharged from this hospital. Only two had a second attack of colic, and both were able to pass the stone spontaneously. In all but one case, hematuria and x-ray evidence of stone had disappeared entirely within seven weeks. In the fifteenth case, hematuria persisted for thirteen weeks and a small renal calculus was retained for forty weeks. Most of the stones disappeared without the patient's knowledge.

TREATMENT

For the acute symptoms, removal of the blocking stone gave complete relief in all cases.

No operative treatment was necessary for any remaining calculi, or in asymptomatic cases in which the stones had been found following the discovery of red blood cells in a routine specimen of urine. The patients were carefully watched for symptoms. The urine was examined repeatedly for the presence of hematuria and frequent flat abdominal roentgenograms were taken. The latter showed the gradual disappearance of any remaining calculi.

No change was made in the course of orthopedic treatment because of an intercurrent renal colic or the discovery of urinary calculi. Turning was encouraged. Ambulation was not hastened, though it was allowed at the earliest time of safe removal of the patient from his spica or traction. The treatment of the fracture or other injury came first. The renal calculus was an unfortunate complication.

Fluids were forced. No attempt was made to limit the calcium intake as this does not materially alter the degree of hypercalciuria. The urine was kept acid, since calcium and phosphorus are known to precipitate out more readily in an alkaline urine. A high vitamin A and B intake was advised to promote epithelization.

SUMMARY

The formation of urinary calculi has proved to be a serious complication in bedrest patients. Thirty-two cases from the orthopedic wards, without urinary infection or abnormality, are reported and five cases are added from nonorthopedic wards. The calculi were usually discovered after the onset of either acute abdominal symptoms suggestive of appendicitis or a typical renal colic, or the passage of a small stone.

We have made the first procedure in the differential diagnosis of acute abdominal symptoms in a bedrest patient the elimination of urinary calculi. Three simple tests are carried out: an examination of the urine for red blood cells, a plain abdominal roentgenogram for radiopaque stone, and an emergency pyelogram for ureteral block. In each case all three steps are carried out, and, in our experience, have been of great diagnostic value.

CESAREAN SECTION: ITS USES AND ABUSES

LT COMMANDER L V DILL

MEDICAL CORPS, UNITED STATES NAVY

ALTHOUGH the earliest phases of obstetrical practice have been lost in antiquity, it seems likely that aid to the laboring woman preceded the written word by many thousands of years and that even the removal of the fetus from the abdomens of women both living and dead was a not unknown, if infrequent procedure. The Talmud gave reference to "delivery through the side," and savage tribes have been observed in the successful practice of abdominal delivery of the fetus. From 1500 on, numerous operations of this type were carried out, rarely successfully, and it was not until 1882 when Sanger suggested that the uterus should be sutured following removal of the products of conception that the first step was taken in the direction of improved maternal mortality. With the development of antiseptics and asepsis, and anesthesia, the last major obstacles were cleared.¹

INCIDENCE AND MORTALITY RATE

Since inception the incidence of the operation has grown steadily, and with each major step forward the procedure has changed from a last resort with almost certain death to mother and fetus to an elective operation with a very low mortality.² Still, however, no standard set of indications for the procedure—nor contraindications—is widely accepted³ and great variation with the part of the country, the stratum of society and the ability of the physician is evident.^{2 3 4 5}

In some areas the incidence is less than 1 per cent, in others it exceeds 10 per cent. In some large hospitals in which both clinic and private cases are delivered side by side by the same doctors, the incidence of section is 2 to 3 per cent higher for the private cases. In general hospitals the incidence is somewhat higher than in lying-in hospitals where the incidence rarely falls below 3 per cent or rises above 5 per cent.^{2 3 5 6}

The mortality rate for both fetus and mother varies much as does the incidence of the procedure. In some clinics it is less than 1 per cent, in others it exceeds 10 per cent. In cases of elective section the fetal mortality is around 2 per cent, which is less than that of vaginal delivery, but the over-all fetal mortality for the operation is from 8.5

From the U S Naval Dispensary, Washington, D C

The opinions expressed here are those of the author and do not necessarily reflect those of the Navy Department

to 10 per cent, a rate made high by inclusion of cases of premature separation of the placenta, placenta previa and toxemia of pregnancy, in which the low survival rate of the fetus is due to the preexisting conditions, not to the operation.⁷

USES

Fetal Indications

Many cesarean sections are done solely because of fetal indications and with the general use of this procedure there has been a tendency to forget how many babies can be delivered vaginally and alive if all convenient procedures such as forceps, version and section were made impracticable or difficult. The accompanying table shows the outcome of over 15,000 deliveries done by Mme Lachapelle in the early 1800's.⁸

COMPARISON OF OUTCOME IN 15,652 SPONTANEOUS AND OPERATIONAL DELIVERIES

Condition	Number	Approximate Per Cent	Living Fetuses	Approximate Per Cent
Total	15,652			95.8
Spontaneous	15,380	98	14,772	96
Forceps	93	0.59	72	77
Version	155	0.99	110	73
Craniotomy	14	0.09	0	0
Pubiotomy	2	(Maternal death)	0	
Section	1	(Maternal death)	1	

Not that we believe that all babies who can possibly be delivered from below should be allowed to do so, for even if the baby is not killed by excessive molding of the head in such cases, the amount of cerebral damage produced by clinical and subclinical hemorrhage and pressure necrosis is unwanted and entirely unnecessary.

Disproportion.—The most frequent indication for the use of the abdominal method of delivery is contracted pelvis with disproportion, and it should be emphasized that a contracted pelvis in the absence of disproportion is not an indication for operative intervention. At the present time, 30 to 50 per cent of all sections are done for this indication, but fewer cases will continue to fall into this classification as better clinical guidance and more extensive use of x-ray pelvimetry are utilized. There should be no problem in deciding the course to follow in the pelvis which is normal or definitely abnormal by clinical measurement or by legitimate x-ray interpretation. It is the borderline case in which careful mensuration and clinical consideration should be utilized.

Once the diagnosis of borderline disproportion is made, the patient

should be given at least four hours of *good* labor. Good labor should not be confused with irregular pains of inefficient quality, but neither should the patient be allowed to have poor and irregular labor for a day or so waiting for the contractions to become effective. If the membranes rupture or good labor does not develop in twelve hours, such a patient should definitely be consigned to having a section or should be classified as definitely able to have the baby by vagina without undue molding. Watchful expectancy can become criminal negligence.

Abnormal Presentations—From 25 to 4 per cent of all sections are done for abnormalities of presentation such as face, transverse or breech. It is common practice to do a cesarean section for all primiparous transverse presentations which cannot be converted to vertical polarity either before or during labor. Multiparas can usually be allowed to deliver from below so long as dilatation is progressing satisfactorily and there is no undue fetal distress or evidence of impending uterine rupture.

Face or brow presentations can also be allowed to deliver so long as labor is progressing satisfactorily, but one could hardly be criticized for the abdominal delivery of a primipara with a face presentation which remains high early in labor.

A breech presentation per se is not an indication for a section. Additional factors such as elderly primigravida, borderline pelvis with large fetus and uterine inertia frequently make section the safest method of delivery, certainly so far as the baby is concerned.

Elderly Primigravida—One of the few instances in which cesarean section can be used to advantage, and of which full utilization often is not made, is the case of the patient who is having her first and probably her last baby. By elderly primigravida we do not mean merely the statistical elderly woman—we mean the patient who is elderly and who has had a long history of relative sterility, or who for some reason is possibly not going to become pregnant again. Such a patient in our opinion should run no excessive risk in getting a live baby. If with a trial labor, all findings being normal, she has fair promise of good labor and easy delivery, then one is justified in allowing delivery from below, but with any other complicating factor, or factors, such as breech presentation, premature rupture of the membranes, uterine inertia or borderline disproportion, we feel that a section is justified, even definitely indicated. Five to 10 per cent of all sections are done for this indication.

Uterine Inertia and Cervical Dystocia—Approximately 2 to 4 per cent of all sections are done for these almost inseparable conditions. On the whole we do not favor the use of section in such cases for we believe that other methods are at hand to deal with all but the rare case of uterine inertia and cervical dystocia. It is obvious, however

that if section is to be done on this indication, the attending physician should make up his mind before the patient has been in labor twenty-four hours, before the membranes have been ruptured twelve hours and before excessive vaginal manipulation has been carried out.⁹

Obstructing Pelvic Lesions—Obstructing pelvic lesions produce indications for 2 to 4 per cent of all sections, and are for the most part made up of ovarian cysts and myomas of the lower uterine segment and cervix.

Prognosticating which tumors will rise from the pelvis during the course of the pregnancy is extremely hazardous, and in the case of fibromyomas of the lower uterine segment, even the onset of labor may not give the true picture. In such cases the picture at the time of, or soon after, the onset of labor should determine the course.

Anti Rh Factor—Since the development of recent knowledge of the Rh factor and its significance in erythroblastosis fetalis many sections are being done to remove the fetus from the noxious influence in the stead of induction of labor.

The anti Rh factor should be closely followed by a legitimate laboratory at biweekly intervals as soon as viability is reached (weekly if the titer is rising), and if a rising titer is encountered the baby should be delivered as soon as possible.

In multiparas in whom delivery by induction from below is without untoward hazard, that should be the method of choice. In primiparas or multiparas in whom induction seems unsafe, abdominal delivery is desirable.

Maternal Indications

With the passing years the so called 'maternal indications' for cesarean section have become more prevalent, although actually they too feature the welfare of the fetus to a great extent.

Previous Section—This category is becoming more and more important each year because of the increasing number of sections which have been done in the past few years and because of the widespread belief in some quarters that 'once a section, always a section' is a hard and fast rule. This indication is utilized for from 10 to 25 per cent of all sections done.

It is our opinion that the patient should be allowed to have the baby vaginally provided disproportion does not exist, that the indication for the original section is no longer present (placenta previa, inertia, etc.), that the puerperium was not febrile, and that the surgeon doing the previous operation used reasonable technic.

Should a patient who has had a previous section develop any additional complication of note during labor, such as an abnormal presentation, uterine inertia, pain or bulging over the scar, it is our opinion that these factors tip the balance and constitute indication for a second abdominal delivery.

Such a patient who is to be allowed to go into labor should be in the hospital at the onset of labor and should be carefully watched during the early hours.

Placenta Praevia—The diagnosis of placenta praevia is found in most series to head the list of maternal indications to the extent of 5 to 10 per cent of the total sections done.

In most quarters the low-lying placenta and the marginal praevias are allowed to deliver from below while the partial and total types are delivered by section. Some groups still elect to deliver partial placenta praevia by vagina, particularly in the multipara, but the difficulty of diagnosis and the high mortality for the fetus (25 to 100 per cent against 5 to 10 per cent by section) is considered by many as definite indication for abdominal delivery.^{10 11}

Finesse and excellence of judgment are necessary in handling such cases, particularly when the first bleeding attack is noted prior to viability of the baby. A course of watchful expectancy under hospitalization until the baby is viable, and the judicious use of the sterile vaginal examination, with the operating room set up to do a section will clarify the diagnosis and combine safety for the mother with advantage to the fetus.

Premature Separation of the Placenta—From 4 to 8 per cent of all abdominal deliveries are done for premature separation of the normally implanted placenta, and the therapy of this condition is subject to a great deal of difference of opinion.¹²

With small areas of separation in which labor is progressing well, we feel that no other therapy is necessary than close observation with operative procedures at hand. Even if complete detachment occurs late in labor and it is felt that delivery from below can soon be effected, the procedure of choice is vaginal delivery.

Extensive separation early in labor with the baby living, or a relatively complete one later in which progress has ceased and delivery cannot be safely effected from below, usually leave no other recourse than section.

Severe Preeclampsia—Abdominal delivery in severe preeclampsia is performed in 4 to 8 per cent of all cesarean sections, primarily for the fetus but frequently on strictly maternal indications.

Conservative therapy of this condition has long proved to be the method of choice, but despite excellent care, cases may progress to the point of convulsions and maternal danger. Before this occurs, induction and delivery from below may be carried out in most cases, but in some individuals the induction of labor may be uncertain and hazardous and section is occasionally a profitable procedure.

Heart Disease—At the present time, section is reserved for those severe cardiacs (group IV of the New York Heart Association) in whom labor is of poor quality or in whom additional complicating

factors such as breech presentation or premature rupture of the membranes weigh heavily in favor of abdominal delivery.¹²

Plastic Vaginal Repairs—This classification is becoming more frequent because of the more extensive use of the vaginal plastic repair and the desire of older women to have babies. From the physical point of view, the plastic repair on the cervix or vagina rarely affects its dilatability, but it is poor economy to have a repair and then let a vaginal delivery disrupt it. We feel that a young woman who has not had all her family should not have a vaginal repair unless absolutely necessary, and then either the repair and sterilization should be done, or she should have a section with any subsequent pregnancy.

ABUSES

Statistics on the abuse of cesarean section have to be drawn from inference, for fortunately there are few people who boast about their misuse of the procedure.

Supposed Disproportion—The most frequent indiscriminate utilization of the method comes under the diagnosis of supposed disproportion. These cases are dwindling with the years, as obstetricians do more of the work, and as there is better antenatal care and wider use of x-ray pelvimetry.

Faced with a floating or slightly dipping head, irregular labor and questionable measurements, it is easily seen how panic develops and section seems the easiest way out. Many of these cases should be classified as uterine inertia, and the cure for the uncertainty should be adequate obstetrical consultation and x-ray pelvimetry.

Prolonged Labor—Neglected—By far the most fatal abuse of section is found in cases of prolonged labor.¹⁴ Many times these individuals have been in labor from twenty-four to 124 hours or more, have had ruptured membrane for several days, and have moderate to marked elevations of temperature.

Even the extraperitoneal operation was not designed for the worst of these cases, for the baby is already dead, dying or badly injured and has a small chance for survival. By all means no transperitoneal procedure should be attempted.

The procedure of choice is the administration of antibiotics, fluids and vaginal delivery when dilatation is completed. Craniotomy, if the infant is dead, may hasten the time of delivery.

Elective Pelvic Procedures—Cesarean section as the mode of delivery in patients who have operable pelvic disease or who need sterilization is never warranted. Several large series have shown that such combined operations take a high toll of maternal life, and that normal delivery followed by the elective procedure in several months, or immediately postpartum if it is sterilization, is preferable.

Prolapsed Cord—Cesarean section is rarely indicated for prolapsed

cord, particularly in the face of uterine contamination by attempts at replacement, poor condition of the fetus by the time the prolapse is discovered, and the conditions under which such emergency procedures have to be carried out. In an elderly primigravida in whom prolapse is discovered immediately, compression is not severe, and the environment is such that a good technic is possible, section is possibly justifiable.

Dead Fetus or Monster.—Unless pelvic contraction is so severe that even with extensive destruction the fetus cannot be removed without probable harm to the mother, cesarean section is definitely contra-indicated in the presence of a known dead fetus or monster. X ray films of the fetus may on rare occasions be of help in identifying such abnormalities.

CONCLUSIONS

It must be understood that the opinions and statements here expressed are formed from the statistics of the past, not of the future, not even of the present, for with the extensive use of better technics, of plasma and antibiotics, the hazards of section are made much less frightening.

The operation now should be used not only to save the lives of babies and mothers which would otherwise be lost, but it also should be used to produce useful members of society where difficult deliveries may obviously do otherwise.

But even as these aids have reduced the hazards of section, they have reduced equally the hazards of normal delivery, and the resultant difference in mortality rate is still many times in favor of the vaginal method. With proper screening of cases, childbearing may be made more profitable and less hazardous.

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CLINICS ON OTHER SUBJECTS

TECHNIC OF THYROIDECTOMY

A Satisfactory Method for the Young Surgeon

J WILLIAM HINTON, M D , F A C S * AND JERE W LORD, JR , M D †

MANY papers on the operative removal of the thyroid gland have been published. One of the most popular and successful methods was described by Halsted¹ and elaborated upon by Reid and Andrus.² Other authors such as Lahey³ have emphasized dividing the strap muscles with wide exposure of the thyroid gland and its surrounding structures such as the common carotid arteries, jugular veins and recurrent laryngeal nerves. Surgeons of experience in the operation of thyroidectomy have found methods which are suitable personally, but for the young surgeon who is still not entirely satisfied with his own technic, the method described in this paper may be of value. The junior author (J W L) found himself in the above position. After having performed some thirty-five partial thyroidectomies by the modified Halsted method² he adopted the method herein described (that of the senior author) with the result that the operation of thyroidectomy became a simpler procedure in his hands. Those residents at the New York Post Graduate hospital who have employed this method of thyroidectomy have not found it difficult to master and their results are entirely adequate.

The method emphasizes exposure of the thyroid gland above all else with complete control of the blood supply. The drawings may aid in clarifying the principles which we feel are important.

1 *Adequate positioning of the patient.* Figure 227 shows the trachea and the thyroid gland thrust forward by means of the elevation of the shoulders and upper back by a folded sheet and hyperextension of the head on the neck. This position is quite similar to the one used for bronchoscopy. A poorly positioned patient can make the entire operation of thyroidectomy difficult.

2 The *incision* is a slightly curved collar incision 3 cm above the sternoclavicular joints and approximately 8 cm in length. It is

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deepened only through the skin and not through the platysma. By means of a sharp-toothed rake retractor the upper flap is dissected away from the platysma and the pretracheal fascia bluntly with a gauze folded over the operator's right index finger. The operator holds the retractor in his left hand during this maneuver. It is important to take the flap upward for at least 2 cm above the thyroid cartilage (Fig. 228). The lower flap is not dissected.

3 The sternohyoid muscles are now separated in the midline by incising the pretracheal fascia throughout the entire length of the incision. This must be carried well above the thyroid cartilage in



Fig. 227—Position of the patient for thyroidectomy

order to have adequate exposure. With a McBurney retractor under the sternohyoid muscles, complete freeing of the gland is carried out bluntly by the fingers, the beginning of which is shown in Figure 229. The right lobe of the thyroid gland is approached first in the operation of subtotal thyroidectomy, this is done by dissecting bluntly with a curved scissors the sternothyroid muscle from the lobe. After the retractor is placed under this muscle the gland is elevated and controlled by means of one or more (as necessary) Lahey clamps. These clamps must not take too large a bite or be closed too tightly or they will tear through the capsule of the gland and cause bleeding.

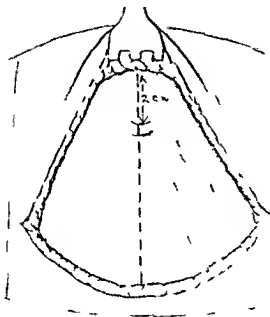


Fig 228—Incision The flap is taken upward for at least 2 cm above the thyroid cartilage

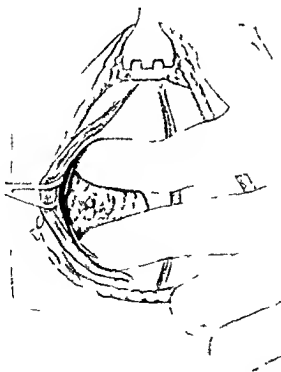


Fig 229—Beginning the freeing of the gland bluntly by the fingers

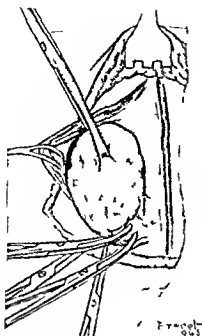


Fig 230—The right lobe of the gland is controlled by a Lahey clamp in the operator's left hand

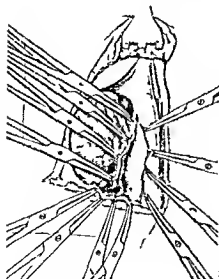


Fig 231

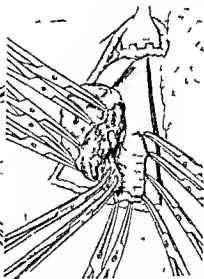


Fig 232

Figs 231 and 232—Dissection of the gland medially dividing the isthmus with a succession of small bites

4 Figure 230 shows the right lobe of the gland controlled by a Lahey clamp in the operator's left hand. The usual method we employ for partial removal of the lobe is to divide the vessels at the lower pole between paired curved clamps, being careful to avoid the recurrent laryngeal nerve which lies posteriorly but may be elevated by the inferior thyroid artery which is elevated in turn by the gland held forward by the Lahey clamp. It is desirable to have some four dozen small curved clamps ("Providence" or "Halsted") available to facilitate subsequent tying of the clamped tissue. The dissection is carried medially dividing the isthmus with a succession of small bites (Figs 231 and 232)

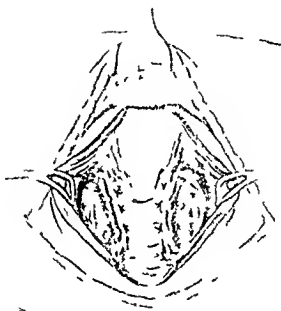


Fig 233—Appearance of the operative field after partial removal of both right and left lobes

5 With the gland now freed at the lower pole and medially, it is deflected caudally so that the upper pole with the branches of the superior thyroid artery is visible. Instead of isolation and dissection of the superior thyroid artery before it branches we prefer to doubly clamp each branch as it courses over the upper part of the lobe both anteriorly and posteriorly. This step is not only easier to perform because of exposure but also is safer in that the ties are placed on several small arteries rather than one large one. We do not have an illustration to demonstrate the above maneuver but following its completion the only remaining step is to cut across the gland in the hori-

zontal plane between paired curved clamps, taking as much of it as seems indicated in the particular patient

In addition to the above mentioned danger of injury to the recurrent laryngeal nerve in the region of the inferior thyroid artery there is a much greater danger of its injury at its entrance into the larynx near the inferior horn of the thyroid cartilage.⁴ To expose the nerve in this area is "anatomically rather difficult with the thyroid gland in place."⁴ The possibility of injury is best avoided by staying away from the posterior capsule of the gland and leaving a small amount of thyroid tissue in this region. After similar partial removal of the left lobe of the gland the operative site appears as in Figure 233

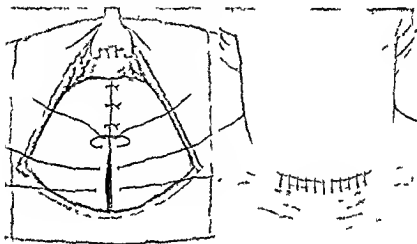


Fig 234

Fig 235

Figs 234 and 235 Closure of the wound by interrupted sutures to the pretracheal fascia and then to the skin

Hemostasis is completely secured, and closure without drainage is effected by interrupted sutures to the pretracheal fascia and then to the skin (Figs 234 and 235). Nonabsorbable suture material is used throughout and we prefer fine cotton. One point should be mentioned and that is the need for absolute hemostasis in the undersurface of the skin flap. A small pressure dressing is applied and the sutures are removed on the second postoperative day.

Following the partial thyroidectomies for nontoxic nodular goiters the patient is ambulatory on the first postoperative day and is discharged from the hospital on the third postoperative day (an average maintained during the past several years). With patients suffering from hyperthyroidism the postoperative course is individualized.

SUMMARY

A method of thyroidectomy is described which makes the procedure relatively safe and simple for the young surgeon. It is based on the two cardinal principles of (1) control of the gland with adequate exposure and (2) absolute hemostasis.

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BILATERAL PARALYSIS OF THE ABDUCTOR MUSCLES OF THE LARYNX ARYTENOIDECTOMY

JOSEPH KELLY, M.D., F.A.C.S.*

IN October, 1939, I attempted to answer the question, "What can we do to relieve patients suffering from bilateral paralysis of the abductor muscles of the larynx, and what results may we expect?" Up to that time my one and only resection of a vocal cord had been a failure, and so, on further consulting the literature on this subject, I found that there had been few successful operations performed and reported. I found out further that the first efforts to correct this condition were directed toward the anterior part of the thyroid cartilage in the region of the anterior commissure. Early attempts had been made to widen the anterior angle of the thyroid cartilage in order to widen the airway. Also attempts had been made to dissect the anterior portion of the vocal cords and transplant them into horizontal slits made in the thyroid cartilage. It seems that the early investigators for the correction of this condition directed their efforts almost entirely to the fixed angle of the thyroid cartilage, whereas we learned later that better results could be obtained by efforts directed toward the posterior portion of the larynx where the soft tissues predominate and where something can be removed to increase the airway in this location.

HISTORICAL DATA

In a search of the literature the first case that I could find in this country in which the arytenoid cartilage was removed in the surgical treatment of bilateral paralysis of the abductor muscles of the larynx was reported by C. H. Baker in 1916. In this instance he removed the

successful operative technics for the relief of bilateral paralysis of the abductor muscles of the larynx. He was many years in advance of any of the successful technics using laryngofissure as the method of approach.

In 1926, C. H. Frazier and W. B. Mosser of Philadelphia reported a series of cases in which they attempted to correct recurrent laryngeal nerve paralysis by nerve anastomosis. These operations were not

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successful because the ideal is difficult to attain, and because it was found that the impulses arrived at as a result of suture and anastomosis went not only to the abductor muscles, but also to the adductor muscles, producing spastic movements of the cords, and left the patient as distressed as he was before the operation. The operations also had a limited use because they could only be employed in those cases in which the surgeon was positive that the nerve ends had not been cut and that he would be able to pick up the severed ends.

In 1922 Chevalier Jackson introduced an operation which he called a ventriculocordectomy, and entitled his paper "A New Operation for the Cure of Goiterous Paralytic Laryngeal Stenosis." In this operation he advised the removal of the true cord and the false cord, without success. In many instances it was followed by such an abundance of scar tissue that cicatricious stenosis resulted.

In 1932 W. B. Hoover of Boston came forward with an operative procedure which he entitled "Operative Treatment by Submucous Resection of the Vocal Cords for the Cure of Bilateral Abductor Paralysis of the Larynx," and in 1938 Hoover and Frank Lahey wrote a paper in which they described their operative procedure as consisting of a submucous resection of the thyroarytenoideus muscle together with the removal of the vocal process of the arytenoid cartilage. They reported eight cases, six of which had been successful, but acknowledged that the speaking voice was not all that could be desired. In 1936, four years after Hoover advised the submucous resection of the muscle tissue of the interior of the larynx, J. M. Lore of New York City published a paper, the title of which was "A Suggested Operative Procedure for the Relief of Stenosis in Double Abductor Paralysis." In this procedure Lore advised the elevation of the mucous membrane over the fibers of the thyroarytenoideus because he felt that the submucous resection was very difficult, and that by his method it was possible to cut down directly upon the tissue to be removed and hemorrhage was more readily controlled, and a more complete removal of the tissue could be made under direct vision. Following the procedure suggested by C. H. Baker in 1916, Dr. Lore advised the complete removal of the arytenoid cartilage.

Until 1939, all surgical attempts to correct the stenosis caused by bilateral abductor muscular paralysis of the larynx had been directed at the interior of the larynx. The first attempt to correct this condition by an extralaryngeal surgical procedure was advocated by Byron T. King in a paper entitled "A New and Function-Restoring Operation for Bilateral Abductor Cord Paralysis." Dr. King suggested the utilization of the principle of substituting a viable muscle for a paralyzed one, and in this particular procedure attached the anterior belly of the omohyoid muscle to the muscular process of the arytenoid cartilage. This procedure appealed to many laryngologists confronted with a case of paralysis of the abductor muscles. A number of opera-

tions were performed by enthusiastic laryngologists but reports of successes were few. Later King modified his procedure by advising a complete mobilization of the arytenoid cartilage by cutting the crico-arytenoid capsule. King's first paper was published in March, 1939 and I believe another paper was published in October, 1939, at which time I was trying to find a safe method for use in a case of bilateral abductor paralysis under my care. I could not see the virtue of trying to attach the omohyoid muscle to the arytenoid cartilage because I felt that the best one could expect would be that the muscle would attach itself to the surrounding tissue and not to the cartilage. However, it did seem to me that if the arytenoid cartilage could be removed by an extralaryngeal route the result should be good.

THE AUTHOR'S EARLY EXPERIENCES WITH EXTRALARYNGEAL ARYTENOIDECTOMY

With this idea in mind I did some work in the morgue to determine the best method for an extralaryngeal arytenoidectomy. In the course of this work I found that if a window were made in the lower posterior third of the thyroid cartilage with its anterior border limited by a line separating the middle and the posterior inferior third of the thyroid cartilage, I came down on the muscular tissue covering the arytenoid cartilage, and that by careful dissection the arytenoid cartilage could be removed through this window with little damage to the intralaryngeal mucous membrane. I found, also, by examining the larynx after this procedure, that the cord on the operated side fell away from the median line and assumed a lower level than the cord on the side not operated upon. I felt that if nature followed her usual course in repairing tissue by obliterating cavities, contraction of the cavity left by the removal of the arytenoid cartilage might give the patient a satisfactory airway.

The first operation using the principle and knowledge gained from this work was performed on November 3, 1939, and the patient was discharged from the hospital on November 15, 1939, at which time she was wearing a stopper in her tracheotomy tube twenty-four hours a day. I could see improvement taking place in her larynx from November 15 until she was sent back into the hospital again on January 4, 1940, for removal of the tracheotomy tube. The tube was removed on the day she entered the hospital, and she was allowed to leave the hospital on January 10, and has since carried on her duties as housewife with little inconvenience. This patient had worn a tracheotomy tube for two years following two operations for thyroidectomy.

After performing this first operation I felt that this procedure could be done under local anesthesia with safety and with little discomfort to the patient. I had the opportunity on February 19, 1940, when a case was turned over to us by our bronchoscopic department. This

patient was a man sixty-eight years of age who had suffered from bilateral abductor paralysis of the larynx and had been wearing a tube for almost a year. He was anxious to have something done because of the severe coughing spells and irritation of his larynx caused by the presence of the tracheotomy tube. He felt that the tracheotomy tube was responsible for his spasms because when he was able to remove it for a while he experienced definite relief.

Immediately following the operation on this patient under local anesthesia he asked for a drink of water, and it was remarkable to me how little interference with deglutition was caused by removal of the arytenoid cartilage. He drank with no evidence of difficulty or distress, and as a consequence he was allowed to remain on full diet with no restrictions during the period of his convalescence. In the first case I used a feeding tube for the first week and was careful with diet for the next week. Since this second operation I have put no restrictions whatsoever on the amount of fluids or food taken by a patient after an arytenoidectomy operation.

EXPERIENCES 1940-1945

Since 1940 fifty-four patients have been operated on by the external arytenoidectomy technic. Forty three of these patients have been my own and they have had my personal supervision throughout their convalescence. I have had five failures in this group most of which took place in the early part of the development of the present technic. Three patients have had a secondary operation without success. However, in another case I reoperated upon a patient who had been operated upon in another hospital, where decannulation had been impossible. I removed the arytenoid cartilage on the opposite side and was able to decannulate the patient.

SPECIAL SURGICAL PROBLEMS AND THEIR SOLUTION

Since starting this work I have had some difficult surgical problems to overcome, and it has been necessary to change the technic in order to insure the best possible result in every case. At the start I did not think it necessary to fix the cord away from the median line of the larynx, believing that the formation of scar tissue would be sufficient to retract the cord and give us a good airway. Now I make this an important part of the operation, and call upon the bronchoscopist to help place a suture below the cord in such a manner that it will give 10 to 12 mm. of space between the cords at the time of operation.

PROCEDURE

The Thyrohyoid Muscle—In the original technic not much thought was given to the thyrohyoid muscle. It was cut and sometimes it was sewed back into position and sometimes it was not. Today it is considered very important to replace this muscle whenever possible, for

it is one of the elevators of the larynx, and elevation of the larynx helps these patients to breathe. It also keeps the larynx from sagging on one side and I believe aids the mucous membrane of the larynx to heal properly. Postoperative observations on larynges of these patients have been very interesting. In some of them it appeared as though the unoperated cord moved when attempts at adduction were made. This may be the case if the unoperated arytenoid cartilage is not ankylosed. The arytenoid prominences remain after the cartilages have been removed. We know from the investigations made by E. F. Ziegler of California and others that the arytenoid muscles receive some branches of the superior laryngeal nerve and that there is an association of this nerve with the ascending branch of the recurrent nerve. It is logical to believe that with nothing to oppose it but soft tissue, the remaining arytenoid cartilage could have a lateral movement to the operated side in the event of coordination between the inferior constrictor muscles of the pharynx and the remaining fibers of the infra-arytenoid muscle.

The Initial Incision—In solving the surgical problems met with in the course of this work the question of where and how to make the initial incision has come up for extensive discussion. I still believe that *the horizontal incision is the incision of choice*, for it gives a much broader and fuller view of the tissues of the neck when dealing with difficult cases.

If the case is one in which a single thyroid operation has been performed by an excellent operator, the pretracheal muscles have not been severed and there was primary healing without distortion and the formation of scar tissue, it is probable that no trouble will be experienced in exposing satisfactorily the muscles covering the thyroid cartilage. However, the right wing of the thyroid cartilage must now be completely exposed and the thyrohyoid muscle reflected upward to expose that part of the thyroid cartilage through which the window is to be made for the extraction of the arytenoid. This is sometimes most difficult to accomplish under the best conditions without using a horizontal incision. When using the straight midline incision an unusual amount of traction must be exerted upon the pretracheal tissue to expose the thyroid cartilage properly or the larynx must be displaced in such a way that it will be a long and difficult task to locate and remove the arytenoid cartilage. I would not advise the midline incision for the beginner.

If, however, a patient who seeks relief of his paralysis has had two or three thyroid operations together with x-ray treatment, the probability is that there is nothing left of the pretracheal muscles but a mass of scar tissue which is adherent to all the surrounding structures, and it may be barely possible to find a line of cleavage along which a cut can be made, even when the horizontal incision is employed. It would, therefore, be impossible to separate and retract this tissue if

a midline incision were used I feel, therefore, that the easiest and proper incision for the expeditious performance of the arytenoid operation is the horizontal incision

In short, fat necks with a small thyroid cartilage and trachea, some difficulty may be encountered occasionally in locating the lower border of the thyroid cartilage. It was a surprise to me when I first had the experience of spending some time dissecting the cricoid cartilage free of scar tissue, thinking it was the thyroid cartilage. This disorientation was brought about by the fact that I was operating upon a short, thick neck, full of scar tissue, where only with the most careful and tedious dissection was I able to expose the upper part of the trachea. This mistake on my part was due to the fact that I had made my incision at the lower border of the cricoid cartilage instead of the lower border of the thyroid cartilage. When I have a difficult case now, I make the horizontal incision longer and dissect the skin and subcutaneous tissues well upward and push my index finger over the trachea and up over the thyroid cartilage until I orient myself by feeling the thyroid notch. This accident may not happen to you, but it may shorten the time of the operation if you will use the patience necessary to insure the proper position for the horizontal incision.

I might add further that the majority of the thirty four patients upon whom I have operated personally have had two or more thyroid operations and their necks were filled with scar tissue, so that most careful dissection was necessary in some of them in order to avoid the vessels within the carotid sheath. In some of these cases the scar tissue will form about the carotid sheath and pull it from under the protecting margin of the sternocleidomastoid muscle. When this happens, care must be exercised not to cut into, or to put the point of a pair of sharp dissecting scissors through the jugular vein. Sometimes the thyroid cartilage itself will be so covered with scar and muscle tissue that it is difficult to expose satisfactorily the area in which the window is to be made. The posterior border of the thyroid cartilage and the attachment of the inferior constrictor muscle may be so thickened and fixed in scar tissue that a satisfactory digital examination for the location of the arytenoid cartilage cannot be made. If circumstances and the case warrant it, a submucous resection of this area may be performed. So far I have tried this in only one case.

Occasionally the arytenoid cartilage will be very elusive, especially in young people. The tissues are soft and pliable, the arytenoid cartilage is freely movable and may be placed rather deeply in a broad larynx.

Under such circumstances the position of the arytenoid cartilage and the facet of the cricoid cartilage may be readily located by placing the index finger of the left hand behind the posterior border of the thyroid cartilage and feeling the upper border of the cricoid cartilage through the fibers of the inferior constrictor muscle. If the

point of the dissecting scissors is then pushed through the fibers of the arytenoid muscles which are exposed after making the window, the position of the arytenoid cartilage may be located and its movement felt between the point of the scissors and the tip of the surgeon's finger. By this means it is easier to find the location of the cricoarytenoid articulation and sever the capsule. In a like manner, the fibers of the arytenoid muscles may be separated and cut to expose the outer surface of the arytenoid cartilage. From there on it is a matter of patience and judgment until the arytenoid cartilage is delivered satisfactorily.

The Window.—When making the window through the thyroid cartilage, care should be exercised not to make it too large. In my earlier cases I was content to place the suture fixing the cord away from the middle line through the external perichondrium of the thyroid cartilage, but now I am fixing this suture by putting it through the cartilage and the perichondrium at the upper part of the anterior border of the window. If the window is too large, the suture may be placed too far forward on the cord to give a satisfactory voice. The factor which led to putting the fixing suture through the thyroid cartilage was the severe paroxysms of coughing which sometimes follow the introduction of a tracheotomy tube into the larynx of a patient who has never before worn one. Occasionally it is difficult to control this coughing and I believe that in one of our recent cases it caused the breaking away of the suture which had been placed through the external perichondrium alone. Because of this complication of cough, I have recently had to remove the tracheotomy tube in one case on the second day, and in another on the third day. Although I have stated that, in my opinion, some of the good results were brought about by keeping the tracheotomy tube in place for as long as four, five or six weeks, in nervous, excitable patients we must choose between what we would like to do and what is the best thing to do for the individual when an emergency arises. *Both of these patients had their tracheotomy tubes corked two hours before the tube was removed. This was done to make sure that there would be no immediate dyspnea.* We find that the corking of the tube alone some times relieves the coughing.

The Best Intralaryngeal Area for Fixation Suture.—The complication of postoperative coughing brings up the problem of the best intralaryngeal area in which to place the fixation suture. If this suture is not put securely into the fibers of the thyroarytenoideus muscle or into the fibrous tissues of the cord itself, it may give way at this point just as well as from the external perichondrium. If the fixing suture is placed too far posteriorly into the muscle fibers of the cricoarytenoideus, it will not be secure and it will be difficult to get the proper separation of the cords without too much distortion of the tissues in the posterior part of the larynx. In the presence of severe

coughing a suture in this area may pull through these muscle fibers. Also, because of its proximity to the inferior constrictor muscle, severe gagging and vomiting may affect its position.

It has been my practice to use the laryngoscope before determining the position in which to place the suture. The anesthetist or the assistant uses the scope and the operator with a small, fine hook pulls the cord from the median line of the larynx at several points. The location giving the desired airway with the least amount of separation of the cords anteriorly is the point of choice. This is usually just anterior to the location of the vocal process of the arytenoid cartilage. It might be of interest to mention here the suggestion of one of the laryngologists watching this operation that we use *more than one suture in fixing the cord*. I think this is a good suggestion and we have followed it in one case. However, we must be careful not to separate the cords too much if we are anxious to retain a good speaking voice.

Closure of the Laryngeal Mucous Membrane—After the cord has been fixed, the closure of the laryngeal mucous membrane is the next step if there have been any lacerations of this tissue. The lacerations should be sutured with a fine eye needle, using No. 000 catgut, and the fibers of the arytenoid muscles should also be pulled together. After the thyrohyoid muscle has been sutured as nearly as possible to its original attachment to the thyroid cartilage, the wound is ready to close. We still use a drain which is removed anywhere from the second to the fifth day.

Correction of Surgical Failures—The next group of surgical problems to be considered are those which we have encountered in attempting to correct our failures by reoperating upon the same side. I have tried this in three cases and failed. In the first case I operated initially in November of 1941 and reoperated in February, 1942. At reoperation I went through the old incision, uncovered the window previously made in the thyroid cartilage, and attempted to put a suture in at the location of the cord and further displace it from the median line of the larynx. This was a failure so far as the patient was concerned. However, I felt that I had accomplished something at the time. This patient later developed a granuloma of the larynx which was removed by our bronchoscopic department. I made no further efforts in secondary operations until after I had had a successful result in a case of laryngeal stenosis.

This was the case of a young man 23 years of age who had a laryngeal obstruction with fixation of both arytenoid cartilages. He had been in the hospital some seventy six times in the course of three years. He had considerable hypertrophy of the mucous membranes of his larynx and a thickening of the thyroid and arytenoid cartilages. It was thought that removal of one or both of the arytenoids might increase the airway. He was prepared for an arytenoidectomy, and at the time of operation it was found that he had an old perichon-

dritis causing the obstruction. One arytenoid cartilage was removed but on laryngoscopic examination the amount of space gained was negligible. I then decided to remove all the cartilage from one side of his larynx and sew the internal perichondrium and the thyrohyoid muscle to the median surface of the pretracheal muscles, hoping that the formation of scar tissue and the fixation of this side of the larynx to the under surface of the muscles mentioned would widen the larynx laterally. The result was most encouraging. Two months following this operation he had sufficient airway to allow us to close a tracheal fistula which had existed since he was two years old—the result of necrosis of the tracheal rings following a diphtherial infection complicated by a tracheotomy. He was able to get a gainful occupation for the first time in his life.

With this experience to justify my again attempting to correct failures by operating on the same side, I reoperated upon two of the early failures within a short time—one a nurse from the South and the other a housewife from upper New York State. In the case of the nurse I removed the right wing of the thyroid cartilage and carried out the procedure of suturing the internal perichondrium of the larynx to the pretracheal tissues as I had done in the young man. In the housewife in addition to removing the right wing of the thyroid cartilage I did a thyrotomy and performed an intratracheal removal of the arytenoid cartilage on the opposite side. Removal of the arytenoid cartilage at this time was done because on laryngoscopic examination at the time of operation, we were unable to widen the larynx by pulling on the sutures put through the internal perichondrium. I thought that the intratracheal removal of the opposite arytenoid cartilage would give me more airway.

The results in these two cases were disappointing. I have not heard from the nurse since three weeks after her operation in 1944, and I take it for granted that her result was not satisfactory. However the lady from upper New York State has been a most grateful and obliging patient. In her case there was a perceptible narrowing of the larynx after this operation and on indirect examination of the larynx the action of the inferior constrictor and cricopharyngeus muscles could be followed through the right side of her larynx. There was a distinct movement of the right side of the larynx each time she gagged or strained when I was examining her. The arytenoid prominence on the right side which prior to the second operation remained firm in its position now drooped toward the interior of the larynx. While both of these patients were between 50 and 65 years of age which I believe is the unfavorable period for consistently good results I am nevertheless convinced that *we must conserve the integrity of the thyroid cartilage, as far as possible, for the success of any operation to relieve bilateral abductor paralysis of the larynx.*

The one point that I did not take into consideration when draw

ing an analogy between the success that I had with the young man with laryngeal obstruction and the possibility of getting results on these two patients by following the same technic, was that in the young man I was dealing with an obstruction and not with a paralysis of the muscles of the larynx.

Recently I have done a secondary operation on a young lady who had two previous operations for the relief of her laryngeal paralysis at another institution. The first operation had been done three years previously by the King technic, and the second operation was done about six or eight months later, using the technic of the arytenoidectomy. Fifteen months later, when she again came to our clinic, we told her that we thought she had sufficient airway to carry on without her tracheotomy tube, but she was reluctant to do this because of the distress that she experienced at night. She was becoming very nervous and felt that she could not hold a position. We finally persuaded her to let us remove the tracheotomy tube without closing the tracheotomy opening and encouraged her to seek employment, which she did. However, after following our advice for some months, she came to the hospital and said she was ready to have her third operation if I thought it would give her more airway. We did the usual arytenoidectomy on her left side.

On exposure of the arytenoid cartilage it was noted that the cartilage was very large and after it was delivered the left cord fell away from the median line, giving the patient sufficient airway without fixation suture. However, in view of the fact that this patient had been operated upon on two previous occasions for the relief of her paralysis, I was hesitant about not putting in a fixation suture although it provided more separation of the cords than I deemed necessary. There is no question of the success of this last operation from the standpoint of an airway, and I am happy to report she has a good voice.

There are two more problems which are worth mentioning at this time. One is the question of primary healing. The other concerns the injection of the intratracheal tissue.

Primary Healing.—I noticed that in two of our elderly patients the wounds did not heal readily. In one the wound broke down and several bits of cartilage were extruded. The wound healed with an ugly scar although the result was very satisfactory. In this particular case we were longer than usual in doing this operation and several times I could feel the heat of the two lights we were using through my rubber gloves but thought nothing about it. However, when in a second case of an elderly person who should have made an uneventful recovery there was trouble with healing, I began to realize that the heat from the lights we were using was drying out and devitalizing the tissues in these old people and preventing primary repair. I have now changed our procedure and we use one light until the thyroid cartilage is exposed and from there on the operation proceeds with the reflected

light of a head mirror. We have had no breaking down of wounds in elderly people since making this change.

Care to be Exercised when Injecting Intra-tracheal Tissues—When doing this operation under local anesthesia and injecting the intra-tracheal tissues through the window made in the thyroid cartilage care must be taken not to inject too much solution. If the tissues are flooded, it is more difficult to locate and extract the arytenoid cartilage and, in separating the cords, too much separation may be present when the fluid has been absorbed and the tissues return to normal.

SUMMARY OF TECHNIC OF ARYTENOIDECTOMY AS PERFORMED AT PRESENT

A horizontal incision is made near the lower border of the thyroid cartilage, extending from the median line of the neck to the anterior border of the sternocleidomastoid muscle. The skin, the platysma myoides muscle and the pretracheal fascia are cut and the pretracheal muscles exposed. The sternothyroid, sternohyoid and superior belly of the omohyoid muscles are separated, clamped and cut after the method of a thyroidectomy. This exposes the thyrohyoid muscle and the wing of the thyroid cartilage. The thyrohyoid muscle is cut and elevated, and a window is made in the lower posterior third of the thyroid cartilage below the level of the thyroid notch, with its anterior border limited by a line separating the middle and posterior inferior thirds of the cartilage. The window is made by cutting with a sharp-pointed knife through the external perichondrium and the thyroid cartilage, and the cartilage is removed with a curette or a small flat-nosed rongeur. The size of the window varies with the size of the larynx. A large larynx usually has a large arytenoid cartilage and a small larynx a small arytenoid cartilage. However, a window $\frac{3}{8}$ inch square is sufficient and not too large in the ordinary case.

The removal of the cartilage brings into view the internal perichondrium of the thyroid cartilage, which overlies the musculature covering the arytenoid cartilage, together with a small branch of the superior thyroid artery and some small veins. This perichondrium is incised with a sharp knife or small scissors and removed. The small branch of the superior thyroid artery is located at about the middle of the upper border of the window. This may be clamped with a small mosquito forceps, but pressure and the application of adrenalin usually suffice. By careful dissection with a pair of sharp pointed medium-sized scissors through the fibers of the thyroarytenoideus and the cricoarytenoideus lateralis muscles, the arytenoid cartilage and the cricoarytenoid articulation are exposed. The capsule of this articulation is severed with the scissors and the arytenoid cartilage tumbled from its articulation. With the aid of hooks the arytenoid cartilage is lifted and freed of its remaining attachments by careful scissor dissection. The mucous membrane covering the vocal process of the

arytenoid is usually the most adherent and the last tissue to be separated. This area represents the posterior limit of the cord which may be identified by a white line above the muscle tissue. It is at this point that nonabsorbable suture such as vitallium wire is paced with a fine ophthalmic needle, and with the aid of the bronchoscopist the cord is pulled away from the median line of the larynx and the suture placed through the cartilage and external perichondrium.

Another suture may be placed through the mucous membrane and the muscle tissue just below the cord and fastened through the fibers of the thyrohyoid muscle after it has been replaced. The pretracheal muscles are sutured together with chromic catgut No 1 or No 2, using mattress sutures. The platysma myoides muscle and the skin may be brought together with interrupted sutures of silk or Deknatel, or the platysma and the pretracheal fascia may be closed together with chromic gut and clips used on the skin. It is good surgery to place a cigarette drain under the pretracheal muscles and leave it in place about five days.

The operation may be performed on either side of the larynx. It is best to operate on the side on which the cord is most fixed. If both cords are equally immobile the right side is selected.

General or local anesthesia may be used. If local anesthesia is selected, the usual preoperative medication is given. The amount and strength of the novocain solution used may be varied with the experience of the operator. Part of the novocain solution used may contain some adrenalin to help control superficial bleeding. Deep injections must be made about the side of the larynx and the hypopharyngeal space as in a laryngectomy.

General anesthesia is given through the tracheotomy tube. If the patient is not wearing a tracheotomy tube, a tracheotomy should be performed under local anesthesia before starting the general anesthesia. The operative field is separated from the field of anesthesia by a sterile sheet sewn or clamped to the skin of the neck below the line of incision. In cases in which general anesthesia is given, an intratracheal tube (Flagg) may be used to fix the arytenoid cartilage, but this is not necessary and, if it is used, more care must be exercised to prevent injury and rupture of the intralaryngeal mucous membrane.

The patients are not decannulated until they can keep the tracheotomy tube corked day and night for three or four days and perform ordinary exertions without discomfort.

CONCLUSIONS

I do not hold that this operation is the best or the only operation for the relief of bilateral paralysis of the abductor muscles of the larynx. We have had fifty-four patients up to the present time operated upon by various operators with forty-seven decannulations,

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nevertheless, I believe that other men will improve on the technic or devise new procedures which may be better. I think that a surgeon should do the operation which he does best and with which he has achieved his greatest success. I have tried in this clinic to give you a complete report on this work of mine as it shapes up to date. It is for your judgment to dictate whether it is worthy of your adoption.

THE SURGICAL TREATMENT OF CHRONIC CONSTRICTIVE PERICARDITIS

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CHRONIC constrictive pericarditis is a disease characterized by a chronic fibrous thickening of the pericardium which is so contracted as to interfere with the normal diastolic filling and systolic emptying of the heart. The result of this interference with normal cardiac action are the signs and symptoms resembling heart failure. Pick, in 1896, emphasized the common findings in this disease of involvement of the liver and ascites and, therefore, it is often called by his name

HISTORICAL NOTE

From a historic viewpoint, however, the condition was accurately described long before Pick's publication. Galen, about A D 160, is said to have observed a scirrhus thickening of the pericardium in a cock and suggested that the same condition might occur in man and interfere with proper cardiac function. Lower, however, in 1669, appears to have been the first to describe the disease in man. He pointed out that in large pericardial effusions the mass of fluid "oppresses" the heart in that it compresses its walls and prevents them from dilating sufficiently to receive blood, that under these conditions the pulse becomes small and finally is suppressed, resulting in syncope and death. He cites the history of a London housewife aged 30 years who over a period of years declined in health with dyspnea, precordial discomfort, weakness, and small intermittent pulse. The only important post-mortem finding was a thick, opaque, and even "callous" pericardium densely adherent to the heart. In 1729, Lancisi added to the clinical picture of the disease by citing the case of a man aged 24 with small pulse, marked engorgement of the jugular veins, and swelling of the abdomen. At autopsy a small heart surrounded by a thickened, adherent pericardium was found. Morgagni, in 1761, reported seven cases of the disease, in one of which at postmortem the heart was "so constricted and confined that it could not receive a proper quantity of blood to pass on." But this author also noted that adherent peri-

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cardium need not necessarily be associated with symptoms and signs, an observation which may have distracted the attention of the medical profession from the importance of the disease, for little mention is made of it for over one hundred years even by such well known clinicians as Corvisart, Laennec and Skoda.

During the first half of the nineteenth century two German physicians, Griesinger and Kussmaul, and two English physicians, Chevers and Wilks, made important observations upon the disease, but these, for some unknown reason, entirely escaped notice. It remained for Pick, in 1896, to stimulate interest in a disease which for so many years had been singularly neglected. He reported three cases and discussed in particular the differential diagnosis between constrictive pericarditis and primary cirrhosis of the liver. The interest he aroused in this condition has continued to the present day.

The idea that surgery might achieve results in a disease which has resisted the efforts of the physician is attributed to Weill, who in 1895 suggested that patients with it might be relieved by resection of the pericardium. Delorme, an internist who seems to have had unusual surgical instincts and whose name is widely known in connection with the operation of decortication of the lung for chronic empyema, not only suggested but insisted between the years 1895 and 1898 that surgery be attempted in this disease. His advice, however, was not immediately followed. Henle in 1907 first attempted the operation, and in 1913 Rehn and Sauerbruch performed resection of the pericardium for chronic constrictive pericarditis, the former successfully. Schmieden followed their lead in 1918, and since that time interest in the diagnosis of the disease and knowledge regarding its surgical treatment gradually has become more general. In this country, Churchill was the first to perform the operation, and he and White in Boston, Beck and his associates in Cleveland, Harrington in Rochester, and Burwell and Blalock in Nashville have shown particular interest in and made important contributions to our understanding of this disease.

SALIENT FEATURES OF CHRONIC CONSTRICTIVE PERICARDITIS

It is not our purpose to go deeply into the cause, pathology, clinical manifestations and diagnosis of this disease. But we are sure it frequently is overlooked and, therefore, some remarks regarding its salient features are perhaps warranted. The cause of the thickened adherent pericardium has been related to tuberculosis in one out of eighteen proved cases in our experience, in five out of thirty-seven cases in White and Churchill's experience, and in twenty-two of twenty-eight cases in Burwell and Blalock's experience. Pneumonia, sepsis, a previous pericarditis with effusion as in five of our cases, all have apparently been causative factors, yet in most of the proved cases the antecedent cause of the condition has not been determined. The pathologic process in the wall of the pericardium gives rise to a

variety of lesions. The pericardium is always thickened, but the thickening may be variable in different parts, being slight in some areas, marked in others. The thickened pericardium may be made up wholly of fibrous tissue or deposits of calcium may occur, giving rise to plaques, sheets or a complete bony shell. It may be slightly adherent to the heart or so densely adherent and fused that a cleavage plane between the heart and its covering cannot be demonstrated. The contraction of the thickened pericardium may implicate the entire heart or chiefly the right ventricle or the great vessels at the base. It is the compression of the heart by its shrunken envelope that gives rise to the clinical manifestations of the disease.

These *clinical manifestations* commonly are dyspnea, increase in the size of the abdomen due to enlargement of the liver and ascites, and edema of the feet, and ankles. Either may be the symptoms of onset, although dyspnea and enlargement of the abdomen are the most frequent. Of the physical signs a nontender, nonpulsating enlargement of the liver with ascites and engorgement of the jugular veins are the most important. The venous pressure is increased. The heart shadow may be small, average, size, but most frequently slightly or moderately enlarged. The cardiac rhythm is usually normal (fourteen cases) but there may be auricular fibrillation (four cases). Abnormal cardiac sounds, such as murmurs, are absent in the majority of cases but there may be a systolic murmur. The blood and pulse pressures are low or may come within normal limits. In one of our series the disease was superimposed on a preexisting hypertension. The paradoxical pulse was present in all our cases. Fluoroscopic examination of the heart shows a diminution in cardiac motion and there may be fixation of the heart in the mediastinum and tugging on the diaphragm and the x-ray film may demonstrate a heart encased in a calcified pericardium. Electrocardiographic studies usually show abnormal records. The QRS complexes have shown a low voltage in seventeen patients and either a low voltage or inversion or flattening of the T waves of the coronary type. The electrical axis shifts only slightly with change in the patient's position, the axis deviation was present to the right in six of our patients, to the left in two, and normal in ten.

In the series of eighteen cases here reported enlargement of the liver occurred in all cases, ascites in fifteen, edema of the extremities in eleven, and pleural effusion in eight. Dyspnea on exertion or at rest was present in sixteen and cyanosis in fourteen. Distention of the peripheral veins and an increase in venous pressure was present in all our patients. With these findings it is apparent that the diagnosis of chronic constrictive pericarditis should be considered in patients with the signs of congestive heart failure, in the absence of the common causes of this condition.

Certain studies of the circulation carried out upon nine patients with chronic constrictive pericarditis by one of us (H. J. S.) have added

On the other hand, the respiration remained regular adequate and unaccompanied by cyanosis. While our experience is as yet too limited to compare different methods of anesthesia in the operation of pericardiectomy, it can be said that ether has been highly satisfactory. In no case did we have the slightest anxiety regarding this part of the procedure. While we did not use intratracheal anesthesia in seven of our cases and our patients failed to suffer any ill effects from the accidental opening of the pleura we are inclined to think that intratracheal anesthesia is desirable. Our experience would indicate that in spite of the greatest care the left pleura in particular is likely to be opened in exposing the pericardium for resection, and that the opening might be sufficiently large to cause respiratory embarrassment.

Approach to and Exposure of the Heart—A greater part of the ventral surface of the heart may be exposed by an approach upon the left side of the thorax and therefore at the primary operation a skin muscle flap is reflected upon this side. The position and extent of the flap may be determined by the position of the heart with reference to the overlying costal cartilages and ribs as determined by the x ray film. We have found it desirable to expose the heart from its base to its apex and therefore it may be necessary to resect inclusively the second to fifth the third to sixth or the second to sixth costal cartilages and segments of the corresponding ribs. The skin muscle flap is formed by incisions which overlie respectively the uppermost and lowermost costal cartilages to be resected and which are connected by a vertical incision corresponding with the mid-sternal line. The major pectoral muscle is freed from the sternum and ribs and reflected laterally with the skin flap. The costal cartilages and segments of the corresponding ribs are resected. Thus far we have done a subpectichondrial and subperiosteal resection and have preserved the intercostal muscles which are divided at the left border of the sternum and together with the perichondrium and periosteum are reflected as an additional flap. The dissection is then carried down to the pericardium along the left sternal border and the fat and connective tissue overlying it are carefully freed and stripped laterally carrying with them the reflection of the left pleura. It is during the course of this maneuver that the left pleura may be torn and therefore it should be carried out slowly and carefully. The pericardium is freed to the left lateral border of the heart from the apex to the base in the course of which the phrenic nerve may be brought into view. Having exposed the left pericardium a similar procedure is carried out over the right side of the heart and to its right border. In doing so the heart is depressed so as to create a space between it and the sternum sufficient to allow the subsequent resection of the pericardium. In seventeen of the eighteen cases subjected to pericardiectomy it was possible to resect the pericardium over the right side of the heart without resecting any portion of the sternum in

one case the resection of the left half of the sternum seemed necessary in order to obtain adequate exposure

In two cases, thus far, we have performed a second operation upon the right side in order to free a greater part of the right heart. One patient, markedly improved but not entirely well five years after his primary operation, was subjected to a second operation and his right ventricle and auricle were completely freed. He seems to be well, for all symptoms and signs present before the second operation have since disappeared and his elevated venous pressure and delayed circulation time have returned to normal. He is able to work without medication but complete recession of the liver under the costal margin has not taken place. The other patient had the second operation approximately eight years after the first. She is greatly improved since the resection on the right side. In each of these two, subjected to two operations, the resection was extended inferiorly to the ridge of pericardium where the first resection ended. Both patients withstood the second operative procedure satisfactorily and are now two and one year, respectively, postoperative.

Resection of the Pericardium—It has been our practice after fully exposing the pericardium to incise it over the left ventricle and devote such time as may be necessary in establishing the most satisfactory cleavage plane between it and the heart muscle. In some cases a satisfactory cleavage plane is at once evident and the mobilization of the pericardium may be proceeded with at once. Again, there may appear to be complete fusion between pericardium and myocardium, making the dissection of the pericardium a time consuming matter. In some cases the pericardium is thickened and fibrous but not calcified, in other cases it is almost a complete bony shell, in still others it is a fibrous membrane containing areas or plaques of calcification of various sizes and distribution. Calcified areas may be present over the right ventricle but not over the left, may occur chiefly about the apex and diaphragmatic border of the heart, or may surround the great vessels at the base. They may be easily separated from the heart muscle or may extend into and involve the heart muscle. It is evident from these considerations that the resection of the pericardium may not be too difficult, or it may be extremely difficult and dangerous.

It has seemed best to us to dissect the pericardium off of the left ventricle first because there is less likelihood of tearing into the left than the right ventricle in starting the mobilization of the pericardium and less danger of overdistention of the left than the right side of the heart. The mobilization is carried laterally so as to free the apex and left border of the heart upward to the base of the heart, and downward to the diaphragm. A region where particular care is necessary is the interventricular groove containing the descending branch of the left coronary artery. It is here that adhesions between pericardium and myocardium may be particularly dense and it is possible, as in

one case in our experience, that a part of the artery may be dissected out of its bed with the pericardium, the division of which might seriously interfere with the heart. Having safely crossed the interventricular groove, the mobilization is carried out over the right side of the heart, to the right, if possible, to the right auricular ventricular groove, upward to the base of the heart, and downward to the diaphragm. It has seemed easiest to us to resect the pericardium in fragments, but we have always carried the line of separation between pericardium and myocardium well ahead of the cut edge of the pericardium in order to maintain a flap which we could bring against and suture to the heart muscle if the latter were inadvertently torn. We have also at times abandoned the attempt to separate a plaque of calcification or a particularly adherent piece of pericardium from the heart, thinking it better to leave it as a patch on the muscle than to risk injury to heart muscle in attempting to remove it.

How much of the pericardium it is necessary to remove in order to achieve satisfactory results is difficult to state. We have removed as completely as possible the pericardium over the left and right ventricle, but in only one recent case have we attempted to remove the adherent pericardium over the auricles. An effort has been made to free the apex, and if possible the dissection is carried well down on the diaphragmatic portion of the pericardium. Only one attempt has been made to go beyond the right auriculo-ventricular groove and we have not attempted to free extensively the great vessels at the base.

Not only may the decortication of the heart be, of itself, a tedious and dangerous procedure, but is made more so because of the necessity of operating upon an organ in constant motion, and one very sensitive to external stimuli. In thirteen of the eighteen patients subjected to operation, the heart beat, as counted at the wrist, varied between 100 and 160 and in all cases was over 130 during the greater period of the operation. In some cases there were periods of paroxysmal tachycardia, in others ventricular fibrillation (EKG), in still others such complete loss of rhythm that the cardiac action could be described only as complete arrhythmia. Periods of transient stoppage of the heart occurred not infrequently, and in the majority of cases the dilatation of the right ventricle and its herniation through the pericardial defect added to the difficulties of the procedure. The manipulations necessary in the mobilization and removal of the pericardium certainly play a role in the irregularity of cardiac action. All the circumstances tend to urge the surgeon to hurry and finish the operation but it is a tendency to be resisted. It has seemed to us wise to pause periodically in the course of the operation in order to allow the heart to regain a more normal rhythm and function.

That great care in the operative procedure is of importance in the success of the surgical treatment of chronic constrictive pericarditis

is evident from the literature. As previously noted, in the 256 cases which we have assembled, seventy-four patients, or 29 per cent of the entire number, died upon the operating table or during the post-operative period. A study of such data regarding the causes of death as are available shows that injury to the heart during operation, wound or other complications, and acute cardiac failure accounted for a high percentage of the deaths. There appears to be little doubt that care in avoiding injury to the heart, gentle manipulation of the heart, and meticulous attention to detail in operative technic are important factors in lowering the mortality.

Closure—In the twenty operations on eighteen patients, bleeding has been controlled as perfectly as possible and closure of the large wound has been with silk and without drainage. In nineteen instances healing of the wound has been per primam, in one case a hematoma developed in the lower part of the wound, followed by a localized superficial infection which did not jeopardize the wound as a whole. In this case there also occurred a moderate-sized left hemothorax—complications resulting from imperfect hemostasis. In the closure of the wound we have retained all the layers reflected, first suturing the intercostal muscle and posterior perichondrium at the sternal border, then the major pectoral muscle and finally the subcutaneous layer and skin. Schmieden not only resects completely the bony thoracic wall but excises the major pectoral muscle, using only the skin and subcutaneous tissues to cover the heart. Churchill resects the bony thoracic wall but retains the pectoral muscle. Both surgeons think a mobile thoracic wall over the decorticated heart is desirable. Our experience thus far in cases followed over nine years, indicates that the reformation of a rigid thoracic wall is not incompatible with satisfactory results.

Postoperative Treatment.—Following operation thirteen of the eighteen patients had a surprisingly smooth and satisfactory postoperative course and their convalescence was practically uninterrupted. In six the immediate postoperative course was complicated by pulmonary or intrathoracic complications such as pneumonia, pneumothorax and serosanguineous effusions. These six patients were ill after operation but at no time dangerously ill. In four of the six patients one or more aspirations of the chest were performed for pneumothorax or pleural effusion. The oxygen tent was used postoperatively following eleven of the twenty operations either because of a mild cyanosis or because the pleura had been opened during operation. At some period during convalescence some accumulation of fluid in the chest, either a simple or a serosanguineous effusion, was noted in fifteen instances, for which aspiration was performed in seven cases. Some degree of fever occurred after eighteen of the twenty operations. Because of signs suggesting parenchymal involvement of the lung, the sulfa drugs were

used in three patients and penicillin in two. Fluids were given by clysis after operation in fourteen patients, not given in four. In one patient only a small blood transfusion of 500 cc was given.

We have avoided intravenous fluids because of the fear of embarrassing the newly released heart by too rapidly increasing the blood volume. In general the diet and salt and fluid intake prescribed before operation were continued for a time after operation. Diuretics were used after operation in fifteen patients and not required in five. The position in bed was according to the comfort of the patient. A slight elevation of the patient seemed the most comfortable.

Improvement in the signs and symptoms of the disease has, in our experience, varied considerably. In seven patients improvement was evident at once or before the expiration of a month, improvement in two did not become pronounced until after the lapse of two or three months, in five not until after six to ten months and in one not until after one year. In two improvement was gradual, in three improvement failed to occur. We have learned not to be discouraged if improvement after operation is not evident at once and rapid.

Results to Date—As previously noted, eighteen patients have been subjected to twenty operations without a postoperative fatality. Of these

- 1 Eight patients are classified by us as cured over periods varying from two to ten years. One of these patients, after being completely cured for three and a half years, died from an unrelated acute generalized peritonitis.

- 2 Six patients are markedly improved over periods of from two to six and a half years. Two of these patients were subjected to second operations, which resulted in further improvement in these two cases. All these patients returned to gainful occupation or to housework. One of these patients died six and a half years after operation from pneumonia.

- 3 One patient was moderately improved after operation but required the continued use of mercurials. He died suddenly seven years after operation. Postmortem was not done.

- 4 Three patients were not improved by the operation. One patient died one year after operation from recurrent pulmonary infarction and two died eleven months and seven months, respectively, after operation from a progression of the disease. In the last two it became fairly evident on their return visits that the operation had failed in its purpose.

- 5 Only one of the four patients in whom the cardiac rhythm was auricular fibrillation, was cured by operation, although the other three were improved. Reversion to normal rhythm did not occur and the continued use of digitalis was required in them to keep the ventricular rate slow. One patient who was cured for eight years was crushed against a motor truck. Following this he developed acute

heart failure and it was found that auricular fibrillation with a rapid ventricular rate was present, the rhythm having been regular when seen at his last follow-up visit before this accident. With the administration of digitalis, heart failure disappeared and remains under control when the patient takes maintenance amounts of digitalis.

To have cured or markedly improved fourteen of eighteen patients subjected to operation (77 per cent) is evidence that surgery has contributed importantly to the therapeutics of a disease which commonly causes death.

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THE PROBLEM OF PAROTID TUMORS

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BETWEEN June, 1943 and January, 1945, twelve patients with parotid tumors were admitted to the Brooke General Hospital. In the group there were four mixed tumors, five recurrent mixed tumors and three recurrent carcinomas. Eight of the twelve patients therefore, exhibited recurrences of their tumors. The first operation was performed either in civilian life or at another military installation. The average duration of time between the last operation and their admission was six and a half months. The longest interval was thirty months and the shortest fifteen days. In most cases the histories suggested the primary operation was for the removal of a small tumor of no consequence. The primary incision was usually located directly over the tumor and averaged about 1 inch in length. In some instances it was clear that a parotid tumor had not been suspected and that when such was found the tumor was incompletely removed for biopsy and the operation terminated. Study of these cases indicates a more accurate diagnosis and a more radical operation would have obviated most of these recurrences.

Diagnosis—The diagnosis of parotid tumor should not be difficult yet many tumors—especially those in the cervical portion of the gland—are erroneously diagnosed as enlarged lymph nodes. A parotid tumor should be suspected in any enlargement within a radius of 45 cm of the angle of the jaw. Mixed tumors usually make their appearance early in the third decade while carcinomas appear in the fifth decade. Most of the cases in this series were exceptions to the above rule. The average preoperative duration of mixed tumors is five to eight years and of carcinomas, three to five years. The tumor may vary in size and consistency. Mobility, to some degree, is usually present. Fixation is suggestive of malignancy. Sialograms may be of great value in relating the tumor to the parotid and in the diagnosis of malignancy.

Recurrence after Treatment—Under certain circumstances mixed tumors of the parotid can be treated with a remarkably low rate of recurrence.

Singleton and Duren¹ have reported a recurrence rate of 87 per cent after surgical excision, Swinton and Warren² 43 per cent, and

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Stein and Geschichter,³ 12.8 per cent. Yet the over-all recurrence rate as given by various other authors is considerably higher (see table). The difference may be attributable to the adequacy of the surgical removal. Recurrences are usually attributed to (1) a multicentric origin, (2) tumor foci in the capsule, (3) de novo occurrence or (4) incomplete operation.

OVER-ALL RECURRENCE RATES AFTER SURGICAL EXCISION

	Per cent	
Wood ⁴	30	
Benedict and Meigs ⁵	31	
Sistrunk ⁶	18	
Stein and Geschichter ³	100	After curettage
Stein and Geschichter ³	57	After enucleation
Stein and Geschichter ³	13	After removal with cuff of normal tissue
Singleton and Duren ⁷	3	
Swinton and Warren ⁸	17.6	
McFarland ⁹	23.2	
Patey ¹⁰	23.6	

Choice of Operative Procedure—The common operative procedure is enucleation. In order to obviate danger to the facial nerve Hybinette recommended enucleating the tumor and then with a sharp scalpel dissecting the entire capsule from the parotid. Numerous solutions such as alcohol, zinc chloride and Harrington's solution are used to flood the field for the purpose of chemically destroying any remaining tumor tissue. All admit the desirability of removing the capsule and a cuff of surrounding gland, yet most condemn the method on account of the danger of injury to the facial nerve. However, Singleton and Duren consider that preservation of the facial nerve is of secondary importance to cure and radically excise the mass with a cautery. Their percentage of facial nerve injuries is high but the effectiveness of their method is attested by a low rate of recurrence.

Other surgeons,^{6, 10, 11} have demonstrated that the tumor can be radically removed yet the facial nerve preserved. In fact, Bailey⁷ and Adson and Ott¹⁰ have devised radical operations for the complete removal of the parotid with preservation of the facial nerve.

Sistrunk⁶ isolated the inframandibular branch and traced it back to the main trunk of the facial nerve. Adson and Ott¹⁰ have extended Sistrunk's operation to malignant tumors. Their excellent illustrations give a very clear understanding of the anatomy of the facial nerve. 'It is surprising to learn that the facial nerve penetrates the lower lobe of the parotid only for a distance of approximately 2 cm., after which the nerve lies underneath on the muscles of the face. From this point, the parotid, together with the skin, may be elevated leaving

the peripheral branches as they lie undisturbed on the facial muscles" Janes¹¹ isolates the nerve at the stylomastoid foramen and traces it forward. Both methods have been used in our cases and we find the method of Sistrunk and Adson easier. However, with greater familiarity with the Janes method, the dissection might be less difficult.

Technic of Radical Excision (Blair and Byars)—A very satisfactory technic is that described by Blair and Byars¹². The skin incision must be adequate (Fig. 236). It starts at a point one third of the distance between the external auditory meatus and the lateral border of the orbit, running back to the point just in front of the meatus. It then

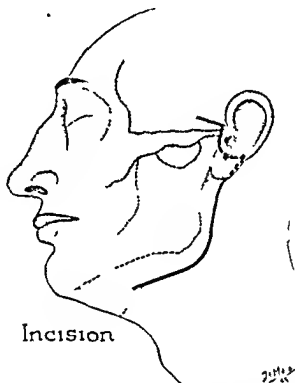


Fig. 236—Incision, relationship to zygoma and mandible

follows the curve of the ear back and behind the lobe of the ear, thence downward along the anterior border of the sternomastoid to a point at about one fingerbreadth below the angle of the jaw, curving forward and parallel to the body of the mandible for a distance of $1\frac{1}{2}$ inches (Fig. 236). This incision gives ample exposure and does not leave a disfiguring scar (Figs. 237 and 238).

The skin flap is dissected forward, scrupulous care being exercised as to hemostasis. The inframandibular branch of the facial nerve crosses the angle of the jaw and then runs parallel below the body of the mandible to the region of the facial artery, where it curves to innervate the lower angle of the mouth. It can be picked up at any con-

venient point along its course anterior to the parotid by gently spreading the tissues with a hemostat. The use of a nerve stimulator is at times helpful in indicating the approximate region in which to begin the dissection.

The nerve is then carefully dissected until the main trunk is reached. This is often tedious and time consuming but was successfully accomplished in each of the twelve cases. Some trauma to the nerve is inevitable and a transitory paralysis of the lower lip is quite common.

When the branches of the nerve are identified the parotid is turned forward and the nerve branches are traced on the masseter muscle.



Fig 237



Fig 238

Fig 237—Scar one month after excision of mixed tumor of parotid gland. Facial nerve is intact.

Fig 238—Facial nerve intact, no disfigurement.

until they disappear under the anterior edge of the parotid. Then the tumor with a generous portion of surrounding gland can be removed en masse (Fig 239). Ducts are ligated as they are cut across. Salivary fistulas are uncommon. None occurred in this series. The portion of the gland separated from the main duct system does not undergo cystic degeneration. In some instances the tumor may be so related to the nerve that a major branch must be sacrificed in order to effect a complete removal. This has not been necessary in our cases. After removal, the tumor is submitted to the pathologist and if carcinoma is found the surgeon must reconsider his position and effect a removal of the remaining portion of the parotid.

The removal of the anterior attachments of the gland and any remaining portion is easy. In order to remove the deep lobe the facial nerve is elevated. The lobe can then be dissected free from the great vessels and the wall of the pharynx. Elevation of the lobe of the ear and section of a few of the anterior fibers of the sternomastoid aid in the exposure. Bailey⁷ recommends a preliminary ligation of the external carotid. In certain instances it may be necessary to sacrifice the nerve and to radically dissect the neck. The prognosis in carcinoma of the parotid is sufficient justification for a more radical approach. At the conclusion of the dissection the wound is flooded with saline. Hemostasis is secured and the flap sutured in place with

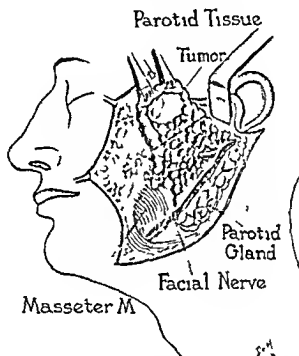


Fig. 239—The tumor and a generous portion of surrounding normal gland are removed

interrupted sutures. The dressing is of the pressure type. The cosmetic result is uniformly excellent.

Radiation Therapy—The value of radiation therapy of parotid tumors is a controversial subject. Variability in the classification of these tumors makes a comparison between individual series of questionable value. Complete surgical removal has offered the best chance for cure. Irradiation therapy should be considered as a palliative substitute for incomplete excision in the group as a whole. Ahlbohm¹³ emphasizes that radiation therapy is occasionally associated with serious complications.

In operable tumors that are excised completely, there is no definite

evidence that immediate postoperative radiation contributes to an improvement in clinical results. There are, however, many reported cases of clinical improvement following radiation to inoperable or incompletely removed tumors (Levin¹⁴ Furstenberg¹⁵ Ahlbohm,¹³ Lederman¹⁵ and New¹⁷)

Inoperable tumors should be irradiated by the roentgen ray or the implantation of radium seeds into the tumor. Such treatment may then result in the reduction of the size of the tumor, making some type of surgical procedure more feasible. Irradiation of incompletely removed tumors is indicated postoperatively or by the implantation of radon seeds into the remaining tumor at the time of operation.

SUMMARY

1 Twelve cases of parotid tumor are reviewed, the importance of correct diagnosis and adequate primary surgical excision is stressed.

2 Radical excision of tumors of the parotid gland with preservation of the facial nerve is emphasized as the treatment of choice.

3 Radiation therapy should be used as a palliative substitute for incomplete surgical excision.

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CONCERNING AMPUTATIONS

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THE review of numerous articles concerning amputations, published since 1942, made necessary in the preparation of this paper, more than compensates for the effort expended. As chairman of the Amputation Committee of the Council on Physical Medicine of The American Medical Association, the author has felt considerable pride in the Handbook on Amputations, published in 1942 by the Association. However, due to the influence of war certain of the concepts expressed in the Handbook must be revised and others may be questioned but on the whole it furnishes an excellent summary of our present day knowledge and practices in amputations.

Amputations are made necessary because of trauma, which leads all other causes, disease, such as thromboangitis obliterans, arteriosclerotic gangrene, with or without diabetes acute arterial occlusions, malignant tumors and severe debilitating or life threatening infections, acquired or congenital deformities, where amputation offers the patient a happier and far more useful life.

In certain of our great medical centers, amputations, especially amputations for circulatory disease and malignant tumors, are considered problems for specialists' teams. Many of our newer concepts concerning amputation in these conditions have come from these centers for peripheral circulatory diseases. But the great majority of amputations throughout the United States are still, and will continue to be, the problem and responsibility of the general surgeon and in the smaller community of the general physician. Most of these men do excellent amputations from the surgical viewpoint. Many either do not understand or neglect the physiological principles necessary to prepare the stump for a useful prosthesis. Many of their patients become confirmed cripples during the months they lie around awaiting the shrinkage of the stump, or waiting to make up their minds as to which artificial leg to buy.

A sympathetic understanding of the psychology of the patient who has lost or is about to lose a part of an extremity, be it ever so small a part, is the first essential toward gaining his confidence. The ability to inspire the patient with an optimistic viewpoint concerning his future, so necessary if his rehabilitation is to be secured, is made easier once confidence is gained.

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The *psychology of the patient's family* must likewise be considered especially the nearest relatives. They are crushed because the loved one has suffered a mangled hand or foot. While the surgeon is justified in amputating at one of the known sites of election, yet to do so without first explaining the reason therefor is foolhardy. When the family or even the patient sees how high above the injured part the amputation has been done, a serious psychological shock often follows which may destroy confidence in the surgeon, or leave a lasting doubt as to whether most of the foot or hand could not have been saved. Therefore make a practice of explaining the nature of the trauma to the patient and his closest relatives, and why it is wise to amputate in the middle of the lower leg or in the lower forearm. Explain the ulcerations and painful stump which usually follow amputation through or just above the ankle. Point out that a properly fitted artificial appliance demands certain sites for amputation. Paint a glowing picture of future usefulness which the modern prosthesis promises. Finally, in the case of the lower leg amputation warn the patient and his family that a fairly high percentage of these stumps require reoperations, usually remodeling of the stump and sometimes even reamputations. Securing teamwork on the part

SITES FOR AMPUTATIONS

The Handbook on Amputations and numerous articles published by British authors since 1942 furnish the best up to date information concerning the choice of sites for amputations. In compiling the Handbook, American surgeons for the first time recognized the need of the closest cooperation with the maker and fitter of artificial limbs in the selection of these sites. The British reports have come largely from their limb fitting center at Roehampton where more than 40,000 leg amputees have been fitted since World War I. Branch centers and certain hospitals have reamputated many stumps in order to meet the requirements for the best type of prosthesis. Thus, the British surgeon has long since learned the lesson of close cooperation with the "artificial limb surgeon." This idea of teamwork is expressed by George Perkins as follows: "Skilful limb manufacturers can fit artificial limbs to stumps of any length or shape, but they tell us that certain limbs look better and function better than other limbs, and that they can only fit these good limbs to stumps of a certain length. In the matter of amputations surgeons must resign themselves to take orders from the experienced limb manufacturers."

As regards major amputations through the upper or lower extremities, the British recognize two sites of election in the arm and two in the leg. In the latter, one is above and one below the knee—the "above-knee" amputation and the "below-knee" amputation. In the arm one site is above the elbow and the other below—the "above elbow" and "below-elbow" amputation.

The Handbook is an epitome of the opinions of the committee members as well as the opinions of twenty-five surgeons and many artificial limb manufacturers who answered questionnaires concerning

amputations Thus, its conclusions are not as simple as those expressed by the British and yet the two are very much in accord

Below Knee Amputations—The middle third of the leg is the optimum site for amputations, according to the Handbook In the adult, this will give a stump varying from between 6 and 7 inches, measured from the medial joint surface of the tibia The British arbitrarily state that the site of election is 5 to $5\frac{1}{2}$ inches below this joint line

Civilian surgeons still persist in making too many of these stumps long, 8 to 10 inches The majority of such stumps are slower in healing because of poor circulation, and tend to ulcerate or to become painful stumps after the prosthesis is worn for a time This is especially true when the amputation is performed through the ankle or in the lower third of the leg

Below knee amputations are the most difficult to perform A fairly high percentage of these stumps must be remodeled or reamputated A stump of only 2 inches will remain in the socket of the prosthesis and will give a serviceable leverage Granting that 5 to $5\frac{1}{2}$ inches is the ideal stump length, the writer prefers a 6 to 7 inch stump for the primary amputation, thus allowing for this possibility of reamputation with a loss of 1 or 2 inches of the bone

In severe traumas of the leg, extending practically to the knee joint, the greatest of surgical judgment is required in choosing between amputation through the lower thigh or a long fight to preserve a part of the tibia with or without the fibula Such severe wounds usually have irregular flaps of skin and fascia which can be molded around the short exposed tibia or tibia and fibula in such a way as to almost completely cover the stump Most of the published articles, especially those coming from the Army, condemn skin grafts or pedicled grafts to cover defects over the end of the stump We believe this type of injury is an exception The situation should be explained to the patient or his family and the possibility of a reamputation above the knee pointed out, followed by an effort to preserve a below-knee stump even if it is only $1\frac{1}{2}$ to 2 inches long The author has had two such cases in children where skin grafts were necessary to complete the closure of the stump Neither has had more trouble with the prosthesis than the average case, and both walk as well as any individual with a 5 inch stump A longer socket, allowing weight bearing on the ischium rather than completely on the tuberosities of the tibia, will protect such stumps As a general rule, skin grafts or pedicled flaps should not be employed on stumps but any effort to preserve $1\frac{1}{4}$ to 2 inches of the tibia below the knee is warranted All artificial limb men do not agree with this statement but one who has had only a $1\frac{1}{2}$ inch stump since childhood is in thorough agreement

Foot and Ankle Amputations—All agree that amputations of the toes are successful Amputations through the foot as high as the tarso metatarsal joints, *Le Franc's amputation*, are warranted, provided a

sufficient amount of the plantar fascia and skin can be preserved to cover over the ends of the bones. Crushing injuries or localized gangrene or infection not permitting a proper covering of the bones with a plantar flap, even though circulation is good, should be treated as a below knee amputation. Amputations through the tarsal bones, ankle or just above the ankle usually are failures. Reamputation is often indicated.

The one exception to this rule may be a good *Syme amputation*. Here the tibia and fibula are sawed through horizontally 1 inch above the ankle joint. The posterior flap, containing plantar skin and other layers of soft tissue covering the heel, is then brought up over the ends of the bones, giving an anterior transverse scar. It is interesting to note that the majority of British authors state that most of the previously performed Syme amputations have been reamputated 5 to 5½ inches below the knee. However, the occasional case will present ideal conditions for this amputation and when performed properly, it gives an excellent stump for the working man who must be on his feet all day.

Above Knee Amputations—"In amputations through the shaft of the femur, the rule is to leave as much bone length as possible" (Handbook). 'The ideal length for an above-knee stump is between 10 and 12 inches, depending upon the height of the patient' (Proceedings of the Royal Society of Medicine). The agreed point of measurement is from the top of the greater trochanter to the end of the femur. Amputations at higher points in the femur, above the main insertion of the adductor magnus muscle, tend to hold the artificial leg in a position of abduction because of the unopposed abductor muscles. Since the main adductor muscle is attached all along the femur, the rule to save as much of this femur as possible is rational.

Disarticulations of the hip are indicated only when conditions make the loss of the entire femur compulsory. Every effort should be made to save at least 3 or 4 inches of the femur when high above knee amputations become necessary. This short stub of the femur, when flexed to a right angle, gives two bony prominences, one anteriorly and the other laterally, the greater trochanter, around which to mold a pelvic socket.

Amputations through the knee joint and the *Gritti Stokes amputation* are seldom if ever indicated. A conical stump fitted into a prosthesis with its knee mechanism in alignment with the normal knee is far better than the prosthesis required for a disarticulation. The Gritti-Stokes amputation with the patella transplanted to the end of the femur, the latter having been sawed through the condyles on a horizontal plane, so often fails to unite or unites in a malposition thus discrediting this otherwise excellent amputation. Like the Syme operation, the British surgeons have reamputated many such stumps. Rogers, who has had personal experience, advocates a disarticulation

with the patella cut into the form of a key so that it fits snugly between and in perfect alignment with the condyles. He claims a natural end bearing stump on integument naturally accustomed to weight bearing. The *Collander* amputation is an excellent operation giving a stump 12 to 14 inches in length, depending upon the height of the patient and affording partial end bearing when desired. If the femur is sawed too short, a flabby stump prone to ulcerate or become irritated and useless for end bearing may result.

As one observes many faulty thigh stumps because of these special operations about the knee joint, he can well understand the growing tendency to form a good conical thigh stump by utilizing equal anteroposterior flaps of skin and fascia for covering the ends of the bone and muscles cut off on the same plane. The resulting stump allows the fitting of a stump controlled prosthesis with weight bearing taken on the tuberosity of the ischium.

Below Elbow Amputations—Considerable controversy exists concerning the site of election in the *forearm*. The British surgeons advocate a stump of 7 inches long measured from the tip of the olecranon. The *Handbook* states: "For the application of an appliance cosmetically resembling a hand the forearm should be amputated at the junction of the middle and lower thirds." Furthermore, the British reports from Roehampton indicate or at least seem to imply that unless 4 inches of the forearm below the elbow can be saved an amputation through the site of election in the humerus is indicated.

Young people, women and professional men think more of appearance and naturally prefer a good looking prosthesis to an oftentimes ugly stump. Working men, draftsmen, artists and similar technicians often prefer a stump that can be of natural assistance to the other hand and usually do not wear the prosthesis except for dress up purposes. Therefore, the author strongly advocates considering each individual case in amputations below the elbow rather than making a general rule for sites of election. When trauma or disease compels the loss of the entire hand and wrist, the 7 inch stump advocated by the British is most ideal from the standpoint of appearance, leverage and other functions of the prosthesis.

When the entire *hand* is mangled and yet sufficient skin especially the ball of the palm can be saved to cover the carpal bones one should think twice before condemning amputations through the hand. In such cases the writer always explains the possible advantage of this small hook of tissue at the end of the wrist as a useful stump in many types of work. An artificial hand with a rather bulky wrist but useless except for appearance can be worn. A better appearing and more useful prosthesis can be supplied if the amputation is performed higher in the forearm. However, it is very questionable if such a prosthesis could equal in usefulness the stub of the hand remaining at the end of the wrist stump. When opportunity permits the surgeon, patient and ar-

tificial limb man should carefully weigh these considerations. In an emergency, we endeavor to save all possible tissue with the idea of reamputation later, provided the resultant stump is a failure. When existing conditions compel amputation within 3 to 4 inches of the elbow joint, one must again consider function versus prosthetic appearance and usefulness. Fortunately, the tendinous attachments of the muscles controlling elbow-joint function are high on the radius and ulna and even a stump of this length will retain flexion and extension ability. A considerable number of individuals who have had congenital amputations just below the elbow get along just as well as the average individual, provided they have one useful forearm and hand. Such individuals rarely show the least concern over the congenitally absent extremity. Furthermore, they rarely wear a prosthesis. One must consider these facts before advocating an upper-arm amputation when only 4 inches of the forearm can be saved.

When amputations of one or all of the *fingers* or *thumb* become necessary, "save all possible length" is the rule with a few exceptions. Amputations of the tips of the fingers, even with the loss of an eighth or a quarter of an inch of the distal phalanx, requires further loss of the bone if an effort is made to secure immediate closure. For years I have thoroughly cleansed such a traumatic amputation with a minimum of debridement. I then cut $\frac{1}{8}$ -inch narrow strips of adhesive, sterilize with iodine the middle portion which will come in contact with the open wound, and then, starting on the flexor surface, carry these strips across the amputated stump. These adhesive strips form bridges with traction, especially on the flexor surface across the open wound at the tip of the finger, continuing across the small portion of the remaining nail or nail bed on to the extensor surface. Granulation tissue forms beneath these bridges with the skin completely closing in in the course of three to six weeks, depending upon the amount of tissue lost. An excellent closure with a minimum amount of deformity results from this method. Skin grafts immediately placed upon such tip amputations are now advocated. When considerable skin has been lost these skin grafts furnish an excellent means of preserving length and covering the bone. I have used both methods but prefer the adhesive bridges in the great majority of cases. In many cases, one can preserve length in the fingers by disarticulation amputations. Occasionally, the cartilage over the end of the proximal surface of the joint undergoes arthritic changes with a painful stump. Therefore, as a general rule, it is wiser to amputate just above the flaring proximal portion of the joint. Effort should be made to preserve the flexor and extensor tendons and unite these over the end of the bone, thus preserving their function. Joint function in all the remaining joints above the amputation is essential, otherwise one may have a partially amputated stiff finger protruding and in the way when the remaining fingers are closed into a fist. Loss of joint function often necessitates reamputation.

In amputations of the *middle and ring fingers*, when none of the proximal phalanges can be retained, many advocate removal of the distal third of their metacarpals. This will give a better appearing hand, provided too much deviation of the index and little fingers toward the middle of the palm does not occur. This is a potential danger. A stronger, more useful hand results if only a small portion of the proximal phalanx of the middle and ring fingers can be saved, held in a position of flexion, if joint function cannot be preserved, or if only the joint surface of these metacarpals is removed.

In the *index finger* it is wise to save all of the metacarpal possible. Again, one must consider whether to leave the joint cartilage intact or to amputate through the head of the metacarpal just proximal to the joint surface.

In the loss of the *entire little finger* a far better cosmetic result can be obtained without loss of strength in the hand, by removing the distal half of the metacarpal in an oblique fashion so as to give a good contour of the ulnar side of the hand.

In the *thumb*, it is of paramount importance to save all possible length. Every effort should be made to cover the stump of the thumb with palmar skin. When impossible, one is justified in resorting to skin grafts or to plastic operations in order to save a portion of the thumb, rather than to remove all of it. Remember, that the ball of the palm, with all or a part of the thumb metacarpal can become very flexible, forming an excellent boss for the apposition of the fingers, providing joint function can be maintained in these. It further affords a good stump for an artificial thumb, although most patients prefer the stump to the prosthesis.

Above Elbow Amputations.—"It is agreed that as much length as possible is desirable in all amputations in the upper extremity" (Handbook). "The ideal length for an above-elbow stump is 8 inches, measured from the point of the acromion process" (British authorities). All agree that as much length of the humerus as possible should be saved but a better conical stump which can be inserted into the socket of the prosthesis is obtained if the amputation is performed in the shaft rather than in the flaring portion of the epicondyles. Necessity may demand higher amputations in the humerus but the higher they are, the harder the control of the prosthesis. Nevertheless, any retention of the upper end of the humerus is far better than a disarticulation at the shoulder joint. Thus, skin grafts or repeated plastic operations are warranted to preserve some type of stump here.

THE AMPUTATION AND THE STUMP

A good stump is one in which the skin and fascia adequately cover the end of the bone or bones, with a scar free of adhesions to the muscles, and so placed that it will not be irritated by the prosthesis and with adequate circulation to prevent a cold, clammy stump, with a tendency to irritation or more often ulceration. Such conditions may exist and yet a poor stump may be present. Too often the surgeon attempts to cover the bone end or ends with too much muscle, tendons, fascia and skin, resulting in a loose, flabby or bulging stump end which makes the fitting of the prosthesis difficult and which is prone to irritation and ulceration, due to the piston action inside the socket of

the artificial limb. Poor stumps in the upper extremity are rare; are seen occasionally in the thigh and are far too prevalent in lower leg amputations.

The Location of the Scar.—When conditions warrant, it should be slightly or completely posterior to the end of the bone except in foot or the Syme operation where preservation of the plantar fascia and skin for the covering of the bones brings the scar anterior.

The artificial limb fitters of Rochampton evidently do not much care where the scar is located provided it is not adherent to the muscles. American artificial limb manufacturers are not as insistent upon scar location as are our American surgeons. Most of the latter insist upon the long anterior and the short posterior flaps which

cause of some
flaps. Insufficient
complete loss

in other or similar amputations a long anterior flap with a posterior scar is used. Otherwise semicircular equal length anteroposterior flaps cut so that the two equal the diameter of the thigh gave the best results. In the upper extremity

or surface skin over the end of
In the forearm and upper arm

Less discussion of scar location and greater emphasis on preserving bone length by manipulating every possible available skin and fascia tissue to cover the bone should be stressed. A very short unorthodox type of stump in the foot or hand below the knee or the elbow is far better than a higher amputation with an orthodox scar.

The Amputation.—The incisions in the skin for the formation of the flaps should first be outlined by a scratch with a scalpel or by a methylene green mark. It is better to cut the flaps too long than too short, since tension over the end of the bone enclosing the flaps must be avoided. Trimming of the flaps to meet the situation is simpler than an immediate reamputation of the bone and muscles in order to close the flaps. Sad experience has taught the author it is better to do this reamputation immediately than to close the flaps with tension. The skin and fascia should be cut through on the same plane rather than forming separate flaps of skin and fascia. The skin fascia flap should be dissected back to approximately 1 inch above the site of sawing through the bone. The muscles are then cut through cleanly and sharply, slightly below the level of the bone site. They promptly retract and the bone is then sawed through horizontally on a level with the cut muscles. For years it was customary to preserve a certain amount of muscle to cover the ends of the bone but experience has taught that such muscle soon becomes only scar tissue. Before sawing the bone the periosteum is cut through approximately 1 inch above the bone site and completely removed thus giving a small length of periosteal bone at the end of the stump. The old practice of covering the end of the bone with periosteum resulted too often in spurs. On the other hand the removal of too much periosteum may result in

an aseptic necrosis at the end of the bone requiring later removal. The author has ceased removing this cuff of periosteum. Instead, he cuts the periosteum through with a knife and then saws the bone through on the same level. Shredding and traumatizing the periosteum is avoided. By beveling the cut margins of the bone and periosteum with a rasp or file, approximately $\frac{1}{8}$ to $\frac{1}{4}$ inch of periosteum is removed.

In below-knee amputations the fibula should be sawed through approximately 2 inches above the tibia and often higher in the case of children where growth of the upper fibula exceeds the growth of the tibia. All artificial limb fitters favor leaving the head of the fibula in situ, thus differing from certain surgeons who favor its removal. Whenever possible, the wise surgeon is guided by the experience of the limb fitters. The distal inch of the short anterior edge of the tibia is cut away obliquely and a rasp is then used to level the remaining anterior surface of the tibia as well as its cut edges. This has prevented discomfort and even ulceration at the point where the skin stretches over the otherwise sharp anterior point of the bone.

Meticulous care is necessary for the *control of all vessels*. The larger vessels are clamped and ligated, often doubly ligated. Chromic catgut, silk, linen or cotton may be used for this purpose, and all have strong advocates. The author has used electrosurgery for the coagulation of the smaller vessels but still ligates the larger vessels. This shortens the operation materially. However, when electrosurgery is used, care must be taken to coagulate the vessels and not large chunks of tissue. The latter leads to necrosis and collections of serum. Serum collections and hematomas are prone to infection and always delay healing. After all visible bleeders are ligated or sealed, the tourniquet should be removed and any further bleeding controlled.

Many methods for the *treatment of the severed nerves* are advocated to prevent neuromas or painful stumps and according to some, phantom extremities. All severed nerves develop some type of neuroma, regardless of treatment. The British surgeons, writing from their experiences at Roehampton, almost unanimously condemn stretching, crushing, ligating or injecting of the severed nerves. One author states that it is far better for the patient if the surgeon never sees the cut nerve. "Avoid further traumatizing of the severed nerve" seems to be the growing tendency. This differs from the teachings of the Handbook. Most recent American authors condemn injection of the nerves with alcohol but continue to advocate ligation of the larger nerves or pulling them down and severing them two or three inches higher than the muscle level. Simply severing the nerve with the muscle and then leaving it alone is worthy of trial. It may be less trouble some than when further traumatized to avoid trouble.

Finally, after all of the above details are completed, the open stump consisting of bone, muscles, vessels and nerves is covered over with

fascia and skin, sometimes loosely with through and through drainage if infection is imminent, other times snugly without drainage. Many advocate local application of one of the sulfa drugs before closing the flaps.

After Care—The most excellent amputation technic may result in failure as far as future function and usefulness of the stump are concerned if the surgeon ceases to be interested after the operation. Below knee, above knee, below elbow, above elbow amputations in the order named, require the special attention of the surgeon until healing is complete and the prosthesis is worn. The immediate dressing of the freshly amputated stump requires pressure and bandaging without impairment of circulation. Personally, for the majority of these stumps, the author prefers a 5-yard roller evenly but not tightly applied to the stump, and held in place by elastoplast. Others prefer the five-tail bandage, or a considerable amount of mechanic's waste, held in place by an Ace bandage. Regardless of what dressing is used the bandaging must be so placed as not to constrict circulation to the stump. Faulty bandaging may result in a bulky, rather than a conical shaped stump or may be the cause of subsequent skin necrosis. It is wise for the surgeon to dress or supervise the subsequent dressings of the amputated case. If properly applied and if the hospital record does not indicate the presence of infection, no dressing may be necessary until the sutures are removed from the ninth to the twelfth day. If drainage has been used it should remain in place five or six days, rather than twenty-four hours, thus establishing a drainage channel. If infection is imminent or present, the writer prefers systemic rather than local use of the sulfonamides, or penicillin started immediately after the operation. Unless contraindicated because of infection, accustom the patient to handle the stump through the dressings and even start pounding the stump on a pillow or directly on the mattress the day following operation. As soon as the wound is healed and the stitches are removed, endeavor to overcome the fear of touching the stump by having the patient bathe and otherwise handle it.

Joint Function—A good amputation stump without preservation of the adjacent joint function may be useless from the standpoint of prosthetic function. Amputations performed just below a joint, especially a major joint, require the greatest consideration for maintenance of joint function. A foot amputation with an ankylosed ankle is worse than a below-knee amputation. A flexion deformity in the stump below the knee, so prone to occur, must be guarded against by some form of splinting of the stump to prevent the deformity. In these cases the author has found suspension of the below knee stump in a sling balanced by weights from a fracture frame an excellent method to prevent flexor deformity. This allows flexion and extension exercises almost from the start, whereas splinting for two weeks may give excellent extension but poor flexion ability. It is imperative to splint the

below-knee stump by some method but when a posterior splint is applied it should be removed frequently for flexion exercises. When a below-knee amputation is complicated by a fracture in the femur, some method of treating the fracture will be necessary which will prevent prolonged immobilization of the adjacent knee joint with the possibility of future ankylosis. Either ankylosis in extension or flexion deformity may ruin the usefulness of an artificial leg.

Physical Therapy—For the majority of amputations physical therapy, in the sense of reporting to technicians for prolonged courses of heat, massage and exercises, is unnecessary. Every good surgeon practices physical therapy when he protects and exercises adjacent joints and when he teaches the patient to pound the stump, first on a pillow, then on the mattress, and finally, on a hard chair. These and many other simple methods of physical therapy are absolutely necessary. In cases where joint function is threatened, where abductor deformity in the thigh has been allowed to develop, or where the patient's timidity prevents handling or hardening of the stump, thus delaying the application of the prosthesis, physical therapy is of paramount importance.

Occupational Therapy—Occupational therapy is or should be indicated in all amputation cases. This may be given in the form of diversional or instructional occupations during the patient's convalescence. Even early return to work is occupational therapy. Many a patient is taught to use his prosthesis properly in the occupational therapy department of St. Luke's Hospital where it is an integral part of the department of physical medicine—a department which represents an exceedingly important branch of treatment in this institution.

The Prosthesis—This should be applied to the stump at the earliest possible moment. The old custom of binding the stump for a long period of shrinkage preliminary to the fitting of the artificial limb is still practiced by many. This long delay often makes the amputee a confirmed cripple. He becomes accustomed to crutches, gets around better with them than when he attempts to wear the prosthesis, and too often unconsciously profits because of his crippled state. A certain amount of shrinkage will occur during the first six months following amputation. In the author's opinion, if the stump is properly formed, maintenance of muscle tone and function by use and exercise will limit shrinkage and give a more useful stump. In the last few years, due to closer cooperation with the artificial limb-fitter, he has had a good temporary socket made which is attached to the permanent artificial leg. This temporary socket costs the responsible party fifty dollars extra. It can be applied early and is worn for six months. Some of my patients never learn to use crutches. When the final shape of the stump has been attained a new permanent socket is then attached to the artificial leg to which the patient has been fully accustomed.

Prior to the development of the Handbook, I was very reluctant to recommend any particular prosthesis. I felt it was better for the patient to look them all over and then choose the limb he desired. His choice too often depended upon the ability of the salesman, while at other times he was confused by the great number of salesmen contacting him. All of this resulted too often in a prolonged delay in obtaining the prosthesis. The ideal would be for each hospital to have its own artificial limb maker and fitter just as many hospitals have their brace departments. In lieu of this the surgeon should study the various artificial limbs made in his community or in the nearest centers where artificial limbs are made. He should study the methods of these manufacturers and their ability to satisfy their patients and especially their continued interest in the case until the prosthesis is satisfactory. In doing this the surgeon will soon find that the great majority of artificial limbs are well made and are applicable to any patient. There are only a few special cases where the amputee must be fitted by special appliances. Having made this study, the author has learned to depend upon approximately three artificial limb manufacturers in his city. When the patient desires another limb he always honors his wishes. The chief point is to know the fitter of the prosthesis and to consult with him concerning the site of amputation and the preparation of the temporary socket and limb so that it will be ready shortly after the stump is healed. In emergency amputations this is impossible but in all others this consultation with the artificial limb surgeon leads to better teamwork in fitting the patient and in teaching him to use the prosthesis.

End Bearing Stumps—Following World War I great enthusiasm developed for end bearing stumps. Such stumps required better location of the scar, avoidance of adhesions to the muscles, early hardening of the end of the stump and its early use, thus preserving muscle tone. These methods were far more physiological than the old practice of prolonged bandaging for shrinkage. The majority of artificial limb fitters were never enthusiastic about end bearing stumps. The author was successful in having a few patients fitted with a prosthesis suitable for end bearing and a few of his patients with ideal stumps practiced end bearing. Full weight bearing on the end of the stump could never be attained. Such patients take about 25 per cent of the weight on the end of the stump. The great majority, however, even when the stump is suitable for end bearing, never use it, too often because of lack of cooperation from the fitters of the limb. The British have given up end bearing stumps altogether. Many of the British authors now advocate taking most of the weight of the prosthesis on the tuberosity of the ischium rather than risking the irritation and the gradual development of bursitis when the weight is borne chiefly on the prominences of the tibia and fibula. More and more American surgeons express unfavorable reactions toward end bearing stumps. The majority of American artificial limb manufacturers still prefer weight bearing directed to the sides of the stump and chiefly to the heads of the tibia and fibula in below knee amputations. Thus, while end bearing may disappear, yet the more physiological stump which it created will persist.

REAMPUTATION

There are many uncontrollable factors which make reamputations or at least remodeling or repair work on the stump necessary. Many of these can be avoided by better technic, but every surgeon is bound to have a certain number of such cases. In other instances the primary amputation is performed in the hope of preserving length but with the cards so stacked that reamputation is a strong probability. Remodeling the soft tissues of the stump is far more common than reamputations. Either operation may be due to one of the following conditions:

1 *A bulky flabby stump* warrants remodeling with a view to obtaining a normal conical stump. Fortunately, reamputation is seldom necessary here.

2 *Sloughing of the skin and fascia* where it stretches over the end of the bone: a form of pressure necrosis is not uncommon, especially in below knee amputations. Impaired circulation due to the original disease, to a too long anterior flap, to removal of too much of the subcutaneous tissue below the skin, or to the presence of a hematoma, often infected, results in a sloughing of one or both flaps, often with complete exposure of the end of the bone.

When mild sloughing or ulceration has occurred, the area usually can be dissected away and a good closure accomplished. However, when the resulting flaps must be closed under tension, or whenever the bone is exposed, reamputation becomes necessary. It is exceedingly difficult to obtain a good serviceable stump by skin grafting or by plastic skin operations in order to close a large ulcerated area, and especially in an effort to cover the bone. It is far wiser to dissect away the ulcerated portion, re-form the best possible flaps, saw away the exposed portion of bone or bones, and re-form the stump regardless of scar location. An exception to this doctrine may be found in the upper extremities where skin grafts and plastic operations may be used to cover the end of the stump, thus maintaining length when necessary, and without unduly interfering with the wearing of the prosthesis. Another exception, which the writer has already referred to, is in the case of a very short below knee stump, especially in young people.

3 *Osteomyelitis*—A persistent sinus, if of long duration, or if it develops weeks or months after healing has occurred, is usually due to bone disease. Aseptic necrosis of the end is the commonest, but true osteomyelitis usually in or near the end of the bone may occur. X-ray examination confirms the diagnosis. Operative removal of the diseased portion is necessary. The use of systemic sulfonamides or penicillin may prevent an infected stump from involving the bone.

4 *Infections*—Pyogenic infections frequently develop in the operative stump due to the presence of a hematoma, or more often, because the amputated part was infected. Such infections may so destroy the flaps as to require remodeling or reamputation.

Gas bacillus infection is the most dreaded of all infections in the amputated stump. When the amputation has been forced because of this infection, it should be done well above the limits of the tissues involved, if possible. Other times a reamputation becomes necessary to re-form the stump destroyed by gas infection. However, the use of refrigeration, x-ray, sulfonamides and (or) penicillin combined always with *anti gas serum* has saved many such extremities formerly amputated. Often all these methods are combined without knowing which one should receive credit for eliminating the infection. X-ray alone is not successful, in my opinion. Refrigeration alone over a period of two or three weeks has completely eliminated a gas bacillus infection, according to personal communications from Crossman and Temple Fay. The writer has used refrigeration, with

occur, the same as with any other anesthetic. The fault is due to the existing impaired circulation or to the fact that the surgeon did not amputate high enough where adequate circulation existed. The technic of refrigeration anesthesia has been described in so many articles that repetition is unnecessary.

Refrigeration Anesthesia without Tourniquet.—Mock, Jr. described the use of ice bags for a few hours over the donor site as a method of anesthesia for skin grafting. In several cases we have applied ice bags tightly about the stump or about an infected area over night, followed the next morning by a reamputation in two instances, or by the opening of the infection in several instances, without any other anesthetic being used. Recently, the writer used refrigeration without a tourniquet for twelve hours as the basal anesthetic in a two and one-half year old child for amputation 5 inches below the knee because of a congenital defect in the leg and foot. Thus refrigeration anesthesia was supplemented with only 1 ounce of drop ether. No manifestation of pain was shown throughout the operation and the baby was awake when returned to the ward.

Surgeons who recognize the dangers of general or even spinal anesthesia in amputations but who fear the use of the tourniquet for so long a time will find refrigeration without a tourniquet, namely, several ice bags kept constantly filled and held to the extremity by bandages for twelve hours, very efficacious in reducing to a minimum the amount of supplemental anesthetic agent needed.

COMMENT

1 The author has endeavored to summarize the best practices of the British and American surgeons in the technic of amputations. It is difficult to add anything new to this, one of the oldest operations in surgery. It is apparent, however, that the surgeon of today is discarding many of the time-honored procedures of the past and is doing a simpler operation with more thought given to stump usefulness and the future wearing of a prosthesis. Closer cooperation with the artificial limb manufacturers has been beneficial both to the surgeon and the patient and undoubtedly has improved the practices of the manufacturers.

2 Recognition that all severed nerves develop neuromas at their cut ends and that efforts to prevent these neuromas are futile, is a fairly new conception. This has resulted in condemnation of methods which further traumatize nerve trunks, such as injecting, ligating, crushing or undue pulling down of these severed nerves.

3 Aperiosteal treatment of the end of the amputated bone has been in vogue for two generations. Used to avoid spur formation at the end of a bone, it was fairly successful. However, aseptic necrosis in this denuded end of bone, even when infection was absent, has been rather

common. The success of the guillotine amputation, where the periosteum is cut clean with the bone, forces the author to predict that the aperiosteal style may pass.

4 So much attention has been given to sites of election and the ideal stump has been expressed in terms of so many inches that short stumps of $1\frac{1}{2}$ to 3 inches below knee or below-elbow have been sacrificed in order to meet the ideal. Every effort should be made to save these short stumps. Often, with careful planning, atypical skin flaps can be saved, closed in about the short bony stump and, in spite of damaged circulation will often live. Even the condemned methods of skin grafting or plastic flaps are justified if thereby a major joint can be saved.

5 In all cases, preservation of joint function without deformity is of paramount importance.

6 Refrigeration anesthesia with tourniquet is an ideal method strongly recommended in elderly people or in other cases in which shock is a problem. Refrigeration anesthesia without tourniquet makes an ideal basal anesthetic which can be supplemented by a minimum amount of either nitrous oxide, pentothal sodium or intravenous morphine, as desired or indicated.

7 Rehabilitation, if successful, must engender a spirit of independence. Independence depends upon working and earning. Therefore, the earlier a patient who has suffered an amputation can be fitted with his prosthesis and returned to work, the more certain his rehabilitation.

PLASTIC OPERATIONS FOR HYDRONEPHROSIS

WILLIAM WALLACE SCOTT, M.D.*

HYDRONEPHROSIS is a term which applies to the renal changes which follow persistent obstruction at any point along the urinary tract. These renal changes are dependent upon the duration of the obstruction and may vary from simple distention in the early stages to total destruction in the late stages of the process. I shall confine my remarks to hydronephrosis caused by obstruction at the ureteropelvic junction.

An attempt at conservative surgery in the management of hydronephrosis secondary to ureteropelvic obstruction was reported as early as 1886 by Trendelenburg. Since this time numerous procedures have been described for the relief of stricture of the ureteropelvic junction. In general all of these procedures have been adopted from general surgery. Kuester in 1891 applied the end to side anastomosis of viscera to the kidney pelvis and ureter. In 1892 Fenger applied the principle of transverse suture of a longitudinal incision to the ureteropelvic junction. Finney and von Lichtenburg popularized continuous side to side anastomosis of pelvis to ureter following the application of this plastic procedure at the pylorus by Finney. The principle of Y plasty as applied to the relief of pyloric stenosis was used as the basis for pelvioureteroplasty by Schwyzer in 1916 and later modified by Foley.

Enthusiasm for plastic surgery at the ureteropelvic junction has waxed and waned and at present appears to be on the upswing. Today's enthusiasm appears reasonable in view of the numerous series of cases recently reported in which evidence is supplied by pyelographic techniques, cultures and careful follow up reports to show that the procedures were justified.

PRELIMINARY CONSIDERATIONS

Diagnosis—The diagnosis of hydronephrosis as with all diagnoses

Gastrointestinal symptoms not infrequently accompany hydronephrosis. Certain cases of hydronephrosis give rise to definite localizing symptoms such as attacks of loin pain, the appearance of a palpable tumor mass and urinary disturbances.

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Once stasis of the upper urinary tract is suspected, its demonstration is readily made by visualization of the renal pelvis and calyx system following the injection of organic iodides opaque to x-ray. This can be accomplished by either the intravenous or retrograde injection of the dye. The intravenous method offers certain definite advantages as well as disadvantages. The ability of a kidney to concentrate diodrast is a good index of kidney function. Good visualization means good function. On the other hand, if the function is sufficiently reduced the pelvis and calices will not be seen and retrograde injection may be necessary. Intravenous urograms when diagnostic have the advantage that there is no possibility of the introduction of infection into a dilated, static collecting system. Catheterization of the ureters provides an accurate method of estimating the size of the hydronephrosis as well as obtaining urine for culture and estimation of function. Adequate visualization is more surely obtainable following the retrograde injection of radiopaque material.

Types of Ureteropelvic Obstruction—Cases of pure hydronephrosis secondary to obstruction at the ureteropelvic junction may be divided into two main groups: (1) those due to *extrinsic causes* and (2) those due to *intrinsic causes*. These two groups may overlap. Extrinsic obstructions are secondary to aberrant polar vessels, fibrous bands, tumor, stone and the like. Although there is considerable difference of opinion with reference to the importance of aberrant vessels as primary etiologic factors, the good functional results obtained in many cases after simple division of the vessel in question seem to prove the importance of this factor. The presence of a stone in the pelvis of the kidney may be secondary to the hydronephrosis, but at times must be considered a primary causative factor.

Intrinsic obstruction of the ureteropelvic junction amounts to a stricture. Apparently stricture formation may occur as a congenital malformation or may be secondary to inflammatory infiltration. Braasch has described a group of cases of hydronephrosis in which he noted hypertonicity of the musculature of the ureteropelvic junction, contraction of which caused a ball valve obstruction by protrusion into the lumen. Presumably this type of obstruction is secondary to defective innervation of the pelvis and ureter and is likened to dyskinesia of the common bile duct and its sphincter. Finally, there are some surgeons who believe that valve formation resulting from a high insertion of the ureter into the pelvis is often the cause of intrinsic obstruction. Others believe that high insertion is a result of pelvic dilatation rather than its cause. Aside from etiological considerations, the finding of high ureteral insertion is of great importance in the selection of the type of plastic procedure to be used.

Selection of Cases for Pelvioureteroplasty—There is almost universal agreement that plastic procedures should be considered in all cases of hydronephrosis secondary to ureteropelvic obstruction excepting those

complicated by suppuration or far advanced hydronephrotic atrophy. Wholesale nephrectomy should be abandoned. The potential function of the hydronephrotic kidney must be considered. Frequently the failure of plastic procedures rests on improper selection of cases rather than the type of procedure used.

Selection of Type of Pelvioureteroplasty—It is impossible to correct the wide variety of pelvic deformities by the use of any one type of plastic procedure. The best results are to be obtained by fitting the procedure to the particular deformity rather than attempting to make all deformities fit one special procedure. A priori two deciding factors are determined preoperatively, namely the presence or absence of infection and the appearance of the pyelogram. I agree with Foley that rotated position pyelograms should be made rather than the conventional anteroposterior views. In an anteroposterior pyelogram the shadow of the dilated pelvis may overlie the ureter and obscure the insertion of the ureter into the pelvis. A final deciding factor is the appearance of the kidney at operation. At times one may find more or less functioning renal tissue than pyelographic studies indicate.

THE OPERATION

Technic—Exposure through the usual loin incision without rib resection is adequate in most cases. Extrinsic obstruction as evidenced by aberrant vessels, fibrous band and so on is dealt with by extensive pelvioureterolysis. This often is curative but I agree with many who insist upon internal calibration of the ureteropelvic junction which is readily accomplished by making a small pelvic incision and passing a No. 10 F urethral catheter past the junction.

If stricture or high ureteral insertion exists as an intrinsic obstruction, a plastic procedure must be considered. Simple stricture may be simply dealt with by longitudinal incision of the area of stricture with transverse closure (Fenger). In all cases a splinting catheter is used as well as a catheter to drain the pelvis.

When faced with a combination of a stricture plus high ureteral insertion, the Foley Y plasty overcomes both of these obstructing factors. After complete pelvioureterolysis a longitudinal incision is made through the lateral aspect of the ureter through the ureteropelvic junction and continuing through the pelvis on its medial aspect. The termination of the pelvic incision is in the form of an inverted V. The length of these incisions is variable depending on the height of ureteral insertion. Generally the ureteral incision is equal in length to that of the pelvic incision plus the depth of the V or the limbs of the Y. Anastomosis of the ureteral and pelvic edges is then made with 000 plain catgut sutures on an atraumatic needle. Stay sutures placed at the distal end of the ureteral incision at the ureteropelvic junction and at the apex of the V shaped pelvic flap aid in approximation. After completion of the anastomosis, a No. 10 F splinting catheter is

placed through a small pelvic incision for a distance of several centimeters down the ureter. A second catheter, usually a No. 16 F. Pezzar, is introduced through a second pelvic incision and becomes the draining catheter.

Catheter Types and Care—Numerous types of catheters have been devised for the purpose of ureteral splinting and pelvic drainage following plastic procedure. The general consensus is that some form of ureteral splinting is necessary. I prefer the use of a No. 10 or 12 F. urethral catheter for splinting and a No. 16 F. Pezzar for pelvic drainage. These are introduced through small posterior pelvic incisions and not through a nephrostomy. Following removal of the splinting catheter the patency of the anastomosis is readily determined by the rapidity with which dye injected through the second or pelvic catheter appears in the bladder.

The principle of a single catheter for splinting and drainage, such as devised by McIver, is sound. At times the splinting portion is hard to introduce because of lack of rigidity. Gibson states that it often crawls back into the pelvis. He advocates the use of a T tube as does Deming. The author has had no experience with this type of tube.

The majority of surgeons maintain splinting and drainage for two to three weeks. Two weeks is sufficient in most instances. In case two single catheters are used the splinting catheter is removed on the fourth day and the draining catheter on the fifteenth day.

One cannot emphasize too strongly the use of urinary antiseptics following plastic operations on the renal pelvis. It appears that a good share of the recent success with plastic procedures is due to the use of the sulfonamides. Penicillin should prove a useful adjunct in the control of those organisms insensitive to the sulfonamides.

Evaluation of Results—In the evaluation of the result of any plastic procedure the criteria observed in order of their importance are (1) the relief of symptoms, (2) the improvement of function, (3) the disappearance of infection, and (4) the disappearance of dilatation. Adequate evaluation therefore requires questioning as to symptoms, repeated pyelograms and microscopic and cultural examination of the urine. Concentration of organic iodides by the involved kidney affords an adequate functional test.

Illustrative Cases

CASE I—A 46 year old housewife had been followed previously for a brief period of time in the gastrointestinal division of the University of Chicago Clinics. For two years she had complained of attacks of right loin pain and dull aching in the left loin. These pains were associated with moderately severe symptoms of bowel distress. Because of the finding of a stone in the region of her left kidney on routine gastrointestinal films intravenous urograms were made. These films revealed a stone 1 cm. in diameter in the left renal pelvis. The right renal pelvis was quite dilated. Decision was made to treat the left kidney first and left pelvolithotomy was unsuccessful. Because of the persistence of attacks of right

loin pain and the presence of considerable pyelectasis and caliectasis, a pelvioplasty of the right kidney was advised.

At operation the renal pelvis was dilated to the size of an orange. A 3 mm. aberrant artery crossed the ureteropelvic junction. Infection of the ureter was 3 cm. from the most dependent portion of the pelvis. Calibration of the ureteropelvic junction revealed a definite stricture. A No. 5 F. ureteral catheter would not pass. Repair consisted of pelvioureterolysis and a Foley Y pelvioureteroplasty. A No. 10 F. urethral catheter was used to splint the ureter and a No. 18 F. Pezzar catheter to drain the pelvis.

This patient made an uneventful recovery. At no time did her temperature exceed 38° C. (100.4° F.). Both catheters were removed on the fourteenth post-operative day and the patient was discharged loin dry and symptom free on the

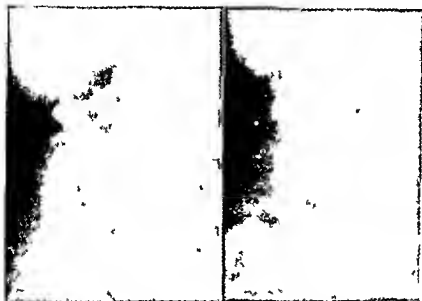


Fig. 240

Fig. 241

Fig. 240 (Case I) —Preoperative pyelogram

Fig. 241 (Case I) —Pyelogram eight months after Foley Y plasty

twentieth day. It is now sixteen months since operation and the patient is symptom free. The urine is negative. Figure 173 illustrates a pyelogram made preoperatively. Figure 174 is a pyelogram made eight months after pelvioureteroplasty. There is marked reduction of pelvic size and good function as evidenced by good concentration of diodrast.

CASE II—A 27 year old housewife was first seen in the urological division of the University of Chicago Clinics with the complaint of intermittent attacks of right loin pain for the previous three years. Inquiry revealed that these attacks were severe lasting fifteen to thirty minutes and associated with nausea. The pain did not radiate, was not associated with frequency, dysuria or hematuria and was not related to meals. Five days prior to this visit she had experienced a very severe attack of right loin pain similar to the previous attacks but lasting three to four hours and requiring morphine for relief.

Physical examination was negative except for a palpably enlarged right kidney. The blood pressure was 130/75. The urine showed a very occasional erythrocyte. An intravenous pyelogram showed a grade II to III right hydronephrosis.

At operation the renal pelvis was the size of a baseball. No aberrant vessels or adhesions were found. The ureter drained the most dependent portion of the pelvis. Calibration of the ureteropelvic junction revealed a stricture. A longitudinal incision was made through the ureteropelvic junction and sutured transversely. This permitted the passage of a No. 10 F. McIver splinting catheter which also served to drain the pelvis.

The entire postoperative course was uneventful, the patient's temperature never exceeding 37.5° C. (99.5° F.). The McIver catheter was removed fourteen days after operation, and the loin was dry and remained so after the fifteenth



Fig. 242.



Fig. 243.

Fig. 242 (Case II).—Preoperative pyelogram.

Fig. 243 (Case II).—Pyelogram six months after Fenger plasty.

day. The patient was discharged on the sixteenth postoperative day. Since operation this patient has experienced no pain and the urine has been negative on repeated examination. Figure 175 shows a pyelogram made preoperatively. Figure 176 is a pyelogram made six months after operation. There is a definite decrease in the degree of hydronephrosis and good function. It is now over one year since operation.

SUMMARY

The subject of hydronephrosis caused by obstruction at the ureteropelvic junction has been reviewed including its diagnosis and plastic treatment. Emphasis has been placed on the desirability of considering a plastic procedure rather than nephrectomy in all cases of hydronephrosis secondary to ureteropelvic obstruction excepting those com-

licated by suppuration or far advanced hydronephrotic atrophy. Careful selection of cases and proper selection of the type of pelvoureteroplasty will be rewarded in the majority of instances by a satisfied patient free from symptoms, free from urinary infection and with a good functional, rather than absent, kidney.

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The
SURGICAL CLINICS
of
NORTH AMERICA

LAHEY CLINIC NUMBER

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THE SURGICAL CLINICS of NORTH AMERICA

LAHEY CLINIC NUMBER

SYMPOSIUM ON COLON SURGERY

INTRODUCTORY REMARKS

FRANK H. LAHEY

THIS Clinic has been particularly interested in diseases of the colon and rectum, as represented by the subjects discussed in this symposium, and has dealt with them in large numbers in late and early stages, together with the complications associated with them, and so the material presented here is the actual product of personal experiences. To anyone who is aware that a very great part of the surgery done in this Clinic is of an elective character, one might wonder where the material for the subject of "Injuries of the Colon and Rectum" might come from in a Clinic such as this. Dr. Colcock, the author of this paper, is particularly qualified to present this subject since he was in charge of a special hospital in the Italian campaign for the care of battle casualties particularly confined to colon wounds.

Perhaps there was nothing about which more was learned in this war than how to manage the injuries of the colon and rectum in battlefield casualties.

During the past few years great progress has been made in the management and care of the lesions of the colon and rectum. In malignancy, the operability rate has been raised, the mortality rate lowered and the five year nonrecurrence rate increased. In spite of this, there is still much advancement to be made in the earlier diagnosis of these lesions and their discovery while they are still in the pre-cancerous stages (polyps and adenomas). Dr. Swinton has shown that in a study of the histories alone in the proven cases of carcinoma of the colon and rectum, they contain in practically every case the statement of a complaint which should have caused the suspicion of the possible presence of the lesion much earlier than it did, and its earlier diagnosis.

When one realizes that we have dealt with nearly 1000 cases of ulcerative colitis, it is evident that we have met and handled all of its phases. We have done ileostomies in the past too late, with resulting mortalities which were too high. We have learned and taught our gastroenterologists that to wait until ileostomy is done as a last resort in ulcerative colitis is to court disaster in a distressingly high percentage of cases, while to do it early in those cases failing to respond to nonoperative measures results in much more satisfactory mortality rates, having them from the previous figure of 26.7 per cent to the present one of 7.5 per cent.

Nothing has made possible the extensive surgery which is necessary for these lesions of the colon and rectum more than adequate relaxation and quiet operating conditions, and to our anesthesiologists, who are by experience and interest particularly qualified to discuss the subject, we are greatly indebted for the favorable operating conditions under which the extensive procedures can be done.

The recent development of curare, sold under the trade name of intercostin with its power of safely paralyzing nerve end apparatus for a brief period, and so accomplishing immediate relaxation of the abdominal wall which will last for fifteen minutes, has more than once made it possible for me to easily close a rigid abdominal wall when the last injection of pontocaine has worn off in continuous spinal anesthesia without the need of introducing another dose. This useful drug which is quite safe in the hands of those experienced with its use and with its ability to bring about quick relaxation of the abdominal wall will I prophesy be used more and more and is an indication of the greater and greater importance of the place of the trained physician anesthesiologist in the surgery of today.

Dr. Bartels discusses anuria and uremia in surgery of the right colon, states which so frequently are associated with removal of the proximal section of the colon which is so intimately associated with fluid absorption. I know of nothing which can postoperatively so quickly convert a patient in good condition into one in bad condition than the unrecognized effects of large fluid losses in the ileostomies so often done with lesions at this level. Nor do I know one which can more quickly correct and restore the patient to a safe state than when these conditions are recognized and properly cared for.

Diarrhea is a condition to which we are altogether too accustomed. It is an indication of a pathologic state within the colon and neglect to investigate its cause has resulted in the unnecessary loss of life in more than one individual. Dr. Kiefer has been interested in and is particularly qualified to discuss this subject.

Of all laboratory evidence that obtained by double contrast enema has been most valuable in colonic and rectal lesions, in its ability so often to delineate the mucosal pattern, its capacity to demonstrate

polyps and to frequently distinguish the obstructions of the sigmoid due to inflammatory lesions from those due to malignancy

While the two conditions, Hirschsprung's disease and intestinal tuberculosis, are by no means common today, their occasional occurrence in our hands has made it necessary to establish plans and procedures for their management

It is unfortunate that in the minds of many men, the term Mikulicz still implies the limited procedures, the implantations of malignancies in the wound, and the incomplete mesentery removal which were associated with the original Mikulicz operations. Having been perhaps responsible for the modifications and extensions of this operation and having personally had as large an experience with it as anyone, I have attempted to demonstrate its usefulness and that employing it as we have extended it and modified it, it is possible to be even more radical with it than one can be by resection and primary anastomosis

In discussing the selection of the operation for cancer of the rectum, I have stressed our conviction that aggressiveness and radicalness supersede any sentiment regarding preservation of the anal sphincter. I have discussed our opposition to the sphincter saving operations so much discussed today and, based upon a large experience with the making of and management of colostomies, asserted that much of the opposition to them is based upon a lack of experience in making and managing them together with an attempt to meet the desires of patients who have no capacity to determine the immediate and ultimate risk that go with these procedures in terms of five year survivals, late and early complications

As may be seen from the titles of the articles in this symposium and from this introduction, this is a field in which all of us, surgeons, anesthesiologists, internists, gastroenterologists, hematologists, roentgenologists and orthopedists, have been interested. It has been a most satisfactory one in the way of the improvement which has been accomplished in it. There still remain, however, great opportunities for improvement in our management of these cases, and in the need for earlier diagnosis by the family physicians who first see them, particularly the patients with malignancies of the colon and rectum, and those patients with ulcerative colitis

The greatest opportunity to improve the results in these cases rests in our ability and effort to educate those physicians and surgeons who see these patients first hand and in their early stages, to demonstrate to them what has been accomplished and to impress upon them that no matter how good the present day results are in surgery of the colon, with their help they can still be greatly improved

SELECTION OF OPERATION AND TECHNIC OF ABDOMINOPERINEAL RESECTION FOR CARCINOMA OF THE RECTUM

FRANK H. LAHEY

SELECTION OF OPERATION

THE selection of operation for patients with a proven carcinoma of the rectum has never been difficult for us since we have never had any interest or sympathy with procedures aimed toward preservation of the sphincter. It has been simple because we have started with the conception that this situation is one which demands the most radical operation possible, unrestricted by any other consideration than the desire to do an operation which will remove the largest possible block of tissue about the malignant lesion. We have placed aggressiveness of approach to a malignancy here and radicalness of removal above all other considerations.

The selection of operation, therefore, in our hands has been solely one of whether or not the patient could stand a complete abdomino-sacral removal of the lesion in one stage or, because of consideration involving a possible fatality, would require a two stage procedure.

As we have become more and more experienced and confident with the operation of abdominoperineal removal of the rectum, we have progressively decreased the number of patients on whom we have employed the *two stage operation* which I devised and described in 1935.¹

There are still, however, occasional cases, not over 15 per cent, in which this operation will prove advantageous. They are particularly those patients who have an abscess or an inflammatory process associated with their lesion. The implantation of the upper loop of the sigmoid or descending colon into the left rectus with the division of the mesentery down to but not through the inferior mesenteric vessels, thus preserving the blood supply to the lower segments, with the implantation of the lower segment of the divided sigmoid above the pubis, together with the suturing of the omentum to the "V" cut in the mesentery to prevent adhesions, will in these lesions permit the diversion of the fecal stream, the quieting down of the inflammatory process in the segregated rectum and the drainage of an abscess associated with the lesion.

By means of this operation the second operation, as we have previously written, in these lesions associated with an inflammatory process or abscess may be approached with the small intestine walled off

in the upper abdominal cavity, with the lesion practically segregated from the rest of the abdomen in the pelvis, and in a patient who as the result of the first stage not only has a well established colostomy which is functioning but has a higher degree of immunity to the infection segregated in the pelvis than would have been the case were this operation attempted in a one stage procedure

We have also occasionally employed this two stage procedure in the extremely fat individual in whom the operation of abdominosacral removal of the carcinoma of the rectum can be as technically difficult as any operation with which I personally have ever dealt. As one becomes experienced with the one stage abdominosacral operation there will be but few cases in which this procedure will be necessary

I can discuss the selection of one stage abdominoperineal resection of the rectum together with the possible selection of an operative procedure for this lesion which is concerned with preservation of the sphincter either by implantation of the upper segment of colon into the perineum or by pelvic anastomosis with the preservation of a rectal stump, by saying that we do not employ the latter operation (preservation of the sphincter), as has already been stated, and for the following reasons. In an experience now with something over 2000 carcinomas of the rectum and colon, we have become more and more convinced that the technical difficulties of removing particularly low large and advanced malignant lesions of the rectosigmoid can be and frequently are very great. If one is to maintain a high operability rate some of these lesions must be removed which are so large as to almost completely fill the pelvis and leave room only for finger and hand dissection. In spite of the fact that the natural spread of carcinoma in lesions of the rectosigmoid is upward, during the period when we did a number of anterior resections leaving the lower segments behind, there were so many recurrences within the lower segment that this operation, anterior resection, avoiding as it does the perineal resection, was ultimately abandoned. As we have stated before we are anxious in operations for carcinoma of the rectum and rectosigmoid to accomplish three things: the removal of the greatest amount of bowel tube, the greatest number of adjacent lymph nodes, and the greatest block mass of adjacent blood vessels.

We are particularly concerned with the latter feature because a follow up study in 1800 cases of carcinoma of the rectum showing 90 per cent five year nonrecurrence rate in the patients with no gland metastases, no adjacent structure metastases and no blood vessel invasion, 37 per cent five year nonrecurrence rate in those with only gland invasion, 30 per cent five year nonrecurrence rate in those with gland and adjacent structure invasions, and 14 per cent five year nonrecurrence rate in those with blood vessel invasion, prompts us to so plan

our operative procedure that we can include not only the greatest amount of bowel tube and gland structure but also the greatest number of blood vessels adjacent above and below the malignant lesion. It is for these reasons that we do not wish to employ any procedure which limits in any way the radical accomplishment of these three features.

We are further opposed to any operation concerned with preservation of the sphincter because of the fact that the upper tube of bowel which must be brought down either into the perineum or for the pelvic anastomosis to the lower stump of rectum, has a blood supply of such character as to either limit the length of tube which can be pulled down based upon its nourishing trunks, sigmoidal or left colic, or when pulled down is nursed solely by its anastomosing marginal branches. We do not believe that one can fail to be in some measure concerned with the amount of sigmoid and ascending colon removed together with their adjacent lymph bearing mesentery, without having in mind whether or not sufficient colon remains to be brought down to the pelvic floor. We wish rather to be in the position where if there are lymph nodes at the root of the mesentery, we can remove rectum, sigmoid and ascending colon, together with its mesenteric root if necessary up to the point where the jejunum becomes retroperitoneal in the jejunal fossa and if necessary, make the colostomy where the descending colon joins the splenic flexure or in the transverse colon. We are further opposed to this procedure by the fact that low extraperitoneal anastomoses below the level of the peritoneal diaphragm have been and will continue, we believe, to be complicated postoperatively by a varying number of strictures and fecal fistulas at this level. In a recent discussion before the Southern Surgical Society on a paper by an author advocating pelvic anastomoses I said and wish to repeat that we are more concerned sentimentally with a higher percentage of five year nonrecurrence rates than we are with the anal sphincter. It has been my experience in life and in surgery, as stated in this discussion, that never does one get something for nothing and it is my conviction that to retain the anal sphincter one pays in the mortality rate and in the five year nonrecurrence rate some as yet to be determined price in the ability to handle successfully advanced cases of carcinoma of the rectum.

It will take a long time to determine by comparable figures whether or not some of these statements which I have made are sound. It will take time to accumulate data regarding mortality, complications and the percentage of recurrences. Even then this will be difficult because comparable statistics will be available and useful only when there is comparable operability. Before leaving this comparison between these two types of operation, I wish only to say that, based upon his own personal interpretation of what the operations offer ultimately in the

above stated final figures available in later years, one must choose today between these two types of operation. We have unhesitatingly chosen the one which attempts to accomplish but one thing, and that is, to cure the greatest number of people of cancer of the rectum by the most aggressive approach to the problem that we can undertake.

As I have stated, a great deal of controversy which will properly and inevitably arise concerning these two operations will be based upon a difference of opinion of how undesirable a colostomy is. We start, after a very large experience with colostomies, very much less prejudiced against it than many who have had less experience with patients who have had colostomies with the lesion removed. I feel very strongly that much of the prejudice against colostomy in the mind of the layman is based, as I have repeatedly stated, upon their experiences with palliative colostomy in which the undesirable features are more the result of the lesion and its consequent complications than of the colostomy itself. It is unfortunately true and will continue to be so that the people who have palliative colostomy are and should be bitterly articulate, together with all of their friends, of how undesirable it is, while the people who have a colostomy after the lesion has been removed and who are so satisfied with it are inarticulate since they are not anxious to advertise to the world that they have had a cancer or that they are different than other people, and so attain positions in the world as objects of curiosity and comment. We, however, who are their confidants know better than almost anyone but the patients themselves how well these people can now be managed with diet, and how active they can be in all of the phases of life with which they were concerned before the colostomy was done. We are confident from a large experience with these colostomy patients that it is now possible to establish colostomies and to educate people in their management so that bags are no longer necessary. I have devoted a considerable portion of this discussion to this feature because the preservation of the sphincter operation has been discussed so much of late, because it has such a sentimental appeal to the patient, because it will have a popular appeal by making many patients accept abdominostomal operations with greater reluctance than such an operation with loss of their sphincter, and because patients have no capacity whatever to comprehend the additional risk we think they take with the more conservative sphincter preserving operation. They have no knowledge of how well colostomies can be managed, and because of these facts I feel the personal responsibility to go so forcibly on record in a comparison of these two procedures.

One of the most difficult decisions to make in patients with obstructing lesions in the sigmoid is that in which one cannot be certain that the obstructing lesion is due to an inflammatory process associated

with diverticulitis or due to malignancy. Frequently diverticulitis is coincidentally associated in carcinomatous lesions and we frequently have this difficult decision to make. A procedure which I have found useful when in doubt in this situation is to cut the sigmoid well above and below the lesion between Ochsner clamps, tying the mesentery midway between the bowel and superior hemorrhoidal artery, give the segment to the pathologist and await an immediate biopsy report. If the lesion be malignant the superior hemorrhoidal artery can be tied below the promontory of the sacrum, the lower end of the rectum closed and covered with a rubber dam and the radical operative procedure continued. If it proves to be due to an inflammatory lesion only either a temporary colostomy with later closure after defunctionalizing the two segments of bowel can be established or if one wishes to undertake the hazard which with the often associated inflammation I think is considerable, an immediate end to end anastomosis can be done. This is a method by which with relatively little risk one can be certain as to the presence or absence of a malignant lesion in an obstruction largely due to an inflammatory process.

LIMITATIONS OF OPERABILITY

No discussion of selection of operation for carcinoma of the rectum or rectosigmoid would be complete or really useful without some remarks on what are the limits of operability in lesions of this sort. Operability in carcinoma of the rectum is related to but a few points. One is how worth while in terms of prolongation of life or possible cure is the operation in the face of an extensive lesion? Second, as the result of the extent of the lesion, is it removable? Third, is the extent of such a character that the structure into which it has spread can or cannot be removed with it?

Perhaps the first discussion should concern the palliative removal of lesions such as carcinoma of the rectum or rectosigmoid in the presence of liver metastases. We have proven in follow up studies here and in a considerable experience with the palliative removal of lesions in the presence of moderate metastases in the liver that these patients live nearly twice as long, are much more comfortable while they live and die infinitely less distressing deaths. We therefore do not hesitate to remove the lesion if there be a limited number of metastases within the liver because of the above fact, but if the metastases be large and numerous we do not believe that it is then good judgment even to do a palliative removal.

I wish to speak particularly of the type of lesion that I am sure when present in patients often results in unjustified rejection of the case as inoperable and that is the type of carcinoma at the rectosigmoid which has leaped against the back of the uterus and involved that structure by contact. This is not a dangerous type of extension

We have now done combined abdominosacral removals of the rectum together with total hysterectomy, including the removal of the tubes, ovaries, and often a considerable part of the vagina in these cases, and it does not materially add to the mortality rate. A number of these patients are now alive and well without recurrence over a number of years. I feel that many surgeons are probably still in the place where I was personally some years ago, again before we had had such a large experience, when I would unhesitatingly have rejected such a case as inoperable.

There is another place where this same situation arises and that is in low carcinomas of the rectum directly over the prostate, in which the central excavation that so frequently occurs in carcinomas of the rectum and colon has continued through into one or both lobes of the prostate. These cases are not to be rejected as inoperable because as the rectum is turned down behind, the entire prostate can be shaved off with a knife or with a fulguration apparatus including that invasive portion of the malignancy which has involved it. We have all employed this maneuver and have patients alive and well over five years in whom this complication has occurred.

Perhaps nothing disturbed me in my early experiences with carcinoma of the rectum more than the large lesions of the rectum which were adherent to the bladder. I was so fearful that such lesions had invaded the bladder that I am sure I rejected some of these that we would now unhesitatingly remove. It is rare that carcinomas of the rectum directly invade the bladder. Even in the late lesion we have been able with good exposure, good light and careful dissection to get the back wall of the bladder off most of these lesions. It is true that in an occasional advanced lesion we have torn holes in the bladder. We have been able to suture them, however, and unless these male patients have an obstructing prostatic lesion most of the posterior urinary fistulas which result have healed. The important feature, I believe, which should determine that a lesion adherent to the bladder is inoperable is that which can be demonstrated by cystoscopic examination, and that is the direct evidence under visualization of infiltration of the posterior bladder wall, as seen through the cystoscope.

One really convincing feature of inoperability in carcinoma of the rectum is fixation, particularly to the lateral wall. When the carcinoma has so extended laterally that on rectal examination it is fixed and extensions can be felt out into the lateral wall, it is truly not removable. Fixation, however, to the hollow of the sacrum does not mean that the lesion cannot be removed. Many of these lesions can be separated by determined effort from the hollow of the sacrum and so mobilized that they can be removed, but if the fixation is firm and with a wide base, this is probably an inoperable lesion.

There is one complicating lesion about which I wish to speak that may occasionally disturb a surgeon who has not had to settle such a situation and that is the type of puckering endometriosis due to an implant upon the rectum with induration invasion nodularity and the firmness which so often characterizes malignancy. This can be settled by biopsy by the demonstration of other plaques of endometriosis and often by putting a sleeve on one arm with an extra glove and with the abdomen open with one finger in the pelvis and the other in the rectum demonstrating that the lesion is an extra bowel implant due to the fact that the mucosa is intact thus aiding in the differentiation between a true carcinoma with its eroded center and raised peripheral edges as opposed to the external implant without erosion of the mucosa that is so often found with endometriosis.

PREOPERATIVE PREPARATION AND ANESTHESIA

One cannot discuss the technical measures related to abdomino-perineal removal of cancer of the rectum without discussing first two very important features (1) preoperative preparation and (2) anesthesia.

Time spent in the few days before operation getting these patients prepared by emptying their bowel regulating their diet and the use of colon antiseptics depending upon whether or not one feels they are necessary is well spent. I wish particularly to warn from my own experience with our own gastroenterologists of the necessity in patients who have even within the previous one or two weeks had barium to be sure that the barium has been completely removed from their colons. Nothing can be more distressing to the surgeon than to have to deal with a sigmoid filled with the firm rock-like masses which one so frequently sees after the administration of barium.

In spite of the fact that these patients have been given castor oil and various other vigorous cathartics we have occasionally found that such preparation had not removed these solid masses and they have presented real technical difficulties in the management of the lesions at the time of operating.

No one who undertakes an abdominosacral operation can ever be sure how long it will take. Some of them can be done quickly and easily and some will take an unexpectedly long time. For that reason we have unhesitatingly chosen fractional spinal anesthesia as the anesthesia of choice for these cases.

This type of anesthesia provides anesthesia of any desired extent. When the abdominal operation is completed a final injection of anesthetic is made insuring thus the continuation of the anesthesia with the needle withdrawn after the patient is turned over so that the

posterior resection can be done in such a time as to be completed before this last dose of spinal anæsthetic wears off.

The satisfaction, the relaxation and quietness provided by this means of anesthesia have been a source of great comfort and convenience to us, and I am sure it has made many of these difficult procedures in fat people and with large lesions very much easier.

There are two or three things that are necessary to mention. One is that the vagina in all women should be carefully prepared because, particularly in women who have had children, with rectoæcetes, the posterior vaginal wall will be very closely adherent to the anterior wall of the rectum. It will often be necessary to put one's finger into the vagina in these cases and there will occasionally be cases in which the vaginal mucous membrane will be punctured. It is therefore desirable that this structure be sterile.

We have always put indwelling catheters in men and women. In both sexes it is desirable that the bladder be collapsed and remain collapsed in order that exposure in the deep pelvis may not be handicapped by bladder distention.

In men it is extremely desirable to have an indwelling catheter in place because as the rectum is separated from the prostate and vesicles and as one approaches the lowest end of the prostate, it is a great comfort to be able to palpate the catheter in the prostatic urethra as it passes beneath the transverse perinei and to be sure to avoid it as the rectum is dissected off the back of the bladder, prostate and perineal muscles from behind.

We have never found it necessary to put ureteral catheters in the ureters in order to identify them. This is largely due to the fact that we are dealing with these ureters constantly. I have many times been asked by men whether or not there is any objection to doing this. I am certain if I were beginning my operative experience with carcinoma of the rectum, that I would unhesitatingly place ureteral catheters in the ureters in order to make their identification in the posterior part of the operation easier. I would have no pride whatever about this, and would much rather take this precaution than the risk of injuring one of them.

THE OPERATION

Abdominosacral Portion.—Our incisions for abdominosacral removal of cancer of the rectum have in the later years all been through the left rectus. The incision is carried well down and well up in order to get adequate exposure, which can be accomplished very satisfactorily through this incision. We have employed a left rectus incision always because through it the dissection can be made and in it the colostomy can be implanted.

With the abdomen opened we have settled operability on the

basis of the size of the lesion, our estimate of its removability, whether or not it has infiltrated into the lateral walls of the pelvis with fixation as we have already discussed, whether or not it is fixed to the sacrum, whether or not it is fixed to the bladder and whether or not it has any degree of mobility. If it has no mobility and is firmly fixed, it is rejected. Further determination is settled on whether or not there are peritoneal implants, the height of nodes involved, the number of nodes involved, the character of the nodes and whether or not there are metastases in the liver.

With the abdomen well open and explored and the determination made that the lesion is operable, it is now important to completely wall off the pelvis by holding back all the loops of small intestine and the head of the cecum in the upper abdomen with large hot wet pads. This provides an exposure similar to that which is obtained in abdominal hysterectomy.

With the wound edges well retracted and with a good light, the sigmoid is now mobilized by severing its lateral attachment as it spreads onto the descending colon and the developmental band which fixes it to the left iliac fossa. As it is turned inward, one first observes the ovarian vessels in the female and the spermatic vessels in the male. These two structures should warn one that the next structure to be seen as one lifts the mesentery of the sigmoid off the pelvic wall is the ureter. Often on the left side this will be found to be very close to the mesenteric roots of the sigmoid.

With the ureter found, it is mobilized outward to the left carefully in order to avoid the possibility of ligating it or including it in the ligature when the root of the mesentery, including the inferior mesenteric vessel is tied.

Such is the position of the right ureter that there is very little likelihood of including it in this mesenteric root ligature. This is not true, however, of the left ureter which is often so close to the root of the mesentery that unless it is mobilized outward to the left, it is in danger of being included in the ligature.

With the ureter visualized it is carefully wiped out and dissected along its lateral course in the pelvis. The lateral fold of peritoneum running from the pelvic wall onto the rectum is incised well down in the female, to the back of the vagina and in the male to the back of the bladder. This accomplishes complete mobilization of the sigmoid and permits one to hold it up so that it hangs by its root. It can now be carefully palpated for nodes and its blood supply in all but extremely fat people plainly visualized and the point on the sigmoid at the junction of the sigmoid and descending colon which is to be selected for the colostomy is now determined. A small rent is made in the mesentery next to the colon and a retaining sling with a gauze strip is placed about it to fix the point at which the two

Ochsner clamps are to be put on the bowel, between which the bowel is to be severed and the proximal end to be the colostomy.

With the sigmoid now pulled to the left, and the pelvis well exposed, the right ureter may be seen passing beneath the peritoneum and along the pelvic wall. The parietal peritoneum on the root of the mesentery and beside the rectum is now incised with long scissors and the dissection of the parietal peritoneum carried down again in women to the back of the vagina and in men to the back of the bladder. Thus and a similar incision on the left are joined across the back of the vagina in the female and across the back of the bladder in the male, and completely separate the rectum from its parietal peritoneal attachments.

A finger is now inserted along the hollow of the sacrum to demonstrate the line of cleavage into the pelvis. It is gradually separated as fingers are introduced into the hollow of the sacrum until the rectum with its mesentery is detached in the hollow of the sacrum down to and beyond the tip of the coccyx.

Attention is now directed to separating the anterior wall of the rectum in females from the back of the vagina and in males from the back of the bladder.

As the peritoneum on the back of the bladder is cut across, joining the two lateral incisions in the pelvic peritoneum to free the rectum from its pelvic attachment, care is taken in the male that this incision is made well up on the back of the bladder and not deep in the fossa of Douglas. It is extremely important to have a flip of peritoneum attached to the back of the bladder which can be grasped with Ochsner or right angle clamps, thus establishing the line of cleavage between the back of the bladder and its attached vesicles and the anterior wall of the rectum. With this fold of peritoneum grasped, it is possible to introduce scissors or one's fingers into this well established line of cleavage, by which the bladder, ureter and vesicles can be pushed forward and the dissection between the rectum and the bladder carried by the fingers well down over the back of the prostate.

In the female the dissection can be carried similarly well down over the back of the vagina.

With the hollow of the sacrum freed from the rectum and its mesentery with the bladder, ureter and prostate in the male separated from the front of the rectum and the vagina from the front of the rectum in the female, the rectum now hangs only by its lateral attachments and with the rectum pulled first to one side and then to the other, these lateral bands and attachments can be severed under direct vision until the middle hemorrhoidal opposite the lower level of the vesicles in the male and the detachment of the rectum from the upper back of the vagina in the female is reached.

With the rectum pulled first to one side and then to the other as

these lateral bands and ligaments are visualized and cut, the ureter on either side can be quite plainly seen, its course visualized and injury to it avoided

With the high operability rate which we have had (83 per cent), there have been many of these lesions removed which have been of such size that the dissection of the pelvis under direct vision was not possible. In such cases the lateral attachments of the rectum can be freed only by finger dissection, and so large has the lesion been in certain of these cases that it has not been possible to demonstrate, clamp and ligate the middle hemorrhoidal vessels at this stage. It has in certain of these cases been necessary to tear these vessels and to control the bleeding posteriorly when the lesion was delivered from behind. There have been certain of them in which no bleeding has occurred following their rupture during the finger dissection. It is, however, not safe to assume that dangerous hemorrhage, if they are not ligated, cannot occur from them. We have had a few cases in which serious bleeding postoperatively has resulted following the removal of very large lesions from unligated middle hemorrhoidal vessels. We believe that in practically all cases these can be found and ligated and that this is the plan of greatest safety, and when not found they should be tied in the posterior operation.

With the hollow of the sacrum freed, with the lesion freed from the back of the vagina in the female or the back of the bladder in the male, with the lateral ligaments all severed, the lesion now readily is lifted out of the pelvis and can be delivered up into the abdominal wound.

With the lesion now freed from its position in the pelvis and delivered the mesentery on or above the promontory of the sacrum, depending upon glandular involvement is now carefully ligated starting close to the bowel, until finally the main trunk nourishing the lower segment, the inferior mesenteric, is doubly ligated with chromic catgut.

We are so anxious in complying with the requirements which I set down early in this paper that is, the removal of the largest amount of bowel, greatest number of glands and the greatest number of adjacent blood vessels that we have preferred to make our colostomy at the junction of the descending colon and the sigmoid, and to remove the sigmoid with its adjacent mesentery so that the ligature of the inferior hemorrhoid is at and frequently above the promontory of the sacrum.

This radical plan of removal results in there being a long loop of bowel frequently above malignant lesions and of such length that it can be reduced into the pelvis between the first and second stages only with difficulty. It has been our custom when this loop is of any considerable length, to resect it, leaving only a small segment above

the lesion, thus diminishing the size of the lower segment which must be implanted in the hollow of the sacrum and covered with the diaphragm of pelvic peritoneum This has proved a very useful step

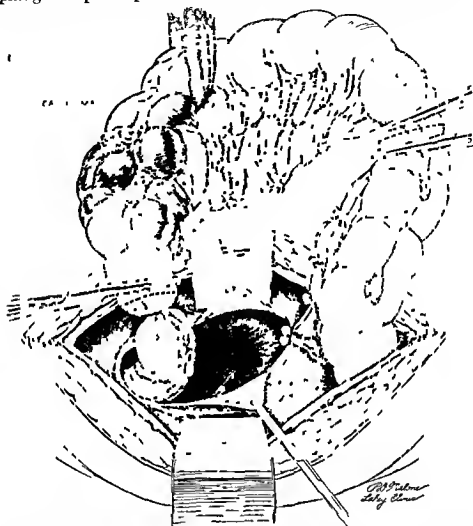


Fig 244—The mobilization of the rectum and sigmoid, together with the tumor, has been completed The blood supply has been tied and a tumor fairly high is purposely shown in order to demonstrate how necessary it is in many of these cases to remove the entire sigmoid in order to obtain adequate removal of bowel tube, node bearing area and adjacent vessels

Note the removal of the tumor with the extra bowel between clamps to avoid having to place such a large amount of bowel in the pelvic cavity

Note also that the lower segment is cut between a ligature of the bowel and an Ochsner clamp This will be cut with the cautery in order that a rubber cover may be put over the lower end, as described in the text

in these cases in which radical removal is accomplished by high ligation of the root of the mesentery and by the excision of a long segment of redundant sigmoid, together with the rectal segment of bowel (Fig 244)

There have been numerous instruments devised whereby a clamp is placed upon the bowel between which one is to sever the colon



Fig 245—The entire extent of sigmoid and tumor shown in Figure 244 has been removed and a rubber cover tied over the upper end of the rectum, the rectum being reduced into the pelvis. Note also that the flaps of pelvic peritoneum, which are to be the diaphragm to cover the rectum reduced into the hollow of the sacrum, are being mobilized. Note the upper end of the sigmoid, covered with gauze, which is to be sutured in the abdominal wound as the colostomy.

When the rectum is completely reduced the rubber covered end will be pushed into the hollow of the sacrum so that it will be next to the coccyx, as stated in the text, and easy to find in the posterior resection.

and reduce the lower end with the clamp attached into the pelvis. An example of this clamp is the De Martel clamp.

We have not employed this for the reason that a good sized metal clamp occupies a good deal of space in the pelvis and as the segment

of bowel implanted in the pelvis is pulled out from behind, can tear pelvic veins and result in considerable bleeding.

We have been much better satisfied with a rubber dam covering tied over the end of the bowel, as shown in Figure 245. This is soft, inexpensive, always at hand, occupies no particular space in the pelvis, and does not have the disadvantage of dragging against the pelvic wall.

In introducing the lower segment of bowel into the pelvis, it is important to push the rubber covered end of the rectum into the pelvis first. This end is guided along the hollow of the sacrum so that it rests just beneath the coccyx (Fig. 245). This is of great advantage in the posterior removal as it presents close to the wound as the incision is made in the pelvic fascia in front of the coccyx, and as the pelvis is entered from behind the rubber covered end of the bowel may be grasped, pulled downward and the rectum delivered from behind so that it hangs only by its attachments to the prostate, the transverse perinei and the levators (Fig. 246, b).

With the lower segment of bowel and rectum reduced into the hollow of the sacrum, one must now obtain a good diaphragm of pelvic peritoneum (Fig. 244). This is best obtained in the male from the back of the bladder and the lateral attachments of the parietal peritoneum to the pelvic wall. These are grasped with Ochsner clamps, the fingers are gently inserted beneath the peritoneum, and it is freed by finger dissection from the pelvic wall, care being taken particularly on the right, since the ureter here has not been demonstrated and is attached to the peritoneum, that that structure is not injured.

There will be no cases in our experience, no matter how extensive the lesion, in which it will not be possible, with persistence and care and gentle dissection with the fingers, to obtain an adequate amount of pelvic peritoneum to close the diaphragm over the reduced segment of rectum.

In the female one may utilize the reflected fold of peritoneum over the broad ligament and in the male one will find a layer of well-established and developed fascia attached to the spermatic vessels on the left which can be freed similar to the way parietal peritoneum can be freed. The left spermatic vessel with this layer of fascia can be sutured to the right leaf of parietal peritoneum and, particularly where the sigmoid has been mobilized from the left iliac fossa, has often in my hands proved extremely valuable in obtaining a good diaphragm to close off the pelvic fossa.

We have learned a few things concerning the establishment of a diaphragm over the reduced segment of rectum. It is not possible to suture this diaphragm in any accepted lines. One must suture in such direction as is possible, based upon the amount of diaphragm of peritoneum and pelvic fascia available. There is one rule, however, which

There have been numerous instruments devised whereby a clamp is placed upon the bowel between which one is to sever the colon

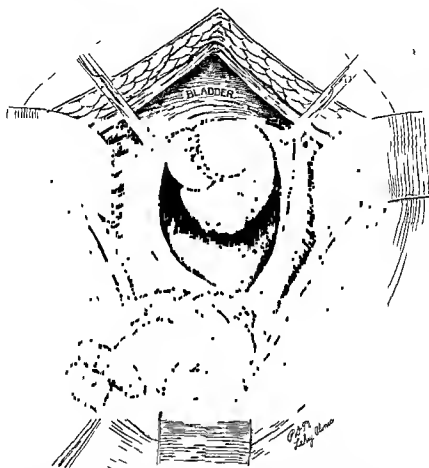


Fig 245—The entire extent of sigmoid and tumor shown in Figure 244 has been removed and a rubber cover tied over the upper end of the rectum, the rectum being reduced into the pelvis. Note also that the flaps of pelvic peritoneum which are to be the diaphragm to cover the rectum reduced into the hollow of the sacrum, are being mobilized. Note the upper end of the sigmoid, covered with gauze, which is to be sutured in the abdominal wound as the colostomy.

When the rectum is completely reduced the rubber covered end will be pushed into the hollow of the sacrum so that it will be next to the coccyx as stated in the text, and easy to find in the posterior resection.

and reduce the lower end with the clamp attached into the pelvis. An example of this clamp is the De Martel clamp.

We have not employed this for the reason that a good sized metal clamp occupies a good deal of space in the pelvis and as the segment

I wish to warn here particularly of the necessity of watching colostomies postoperatively. Since all colostomies live on a limited blood supply, so often the marginal vessel which runs along the mesentery, it is important that colostomies be inspected daily for at least five or six days against the possibility that as the result of coughing and vomiting the mesenteric root of the colostomy has been torn, resulting in the loss of its blood supply.

Should a black bowel be seen within the first four days, it is always possible to reopen the wound, pull out adequately nourished bowel and again implant it in the wound. Should one wait, however, for five or six days when the necrotic bowel has sloughed before discovering it, it can result in perforation, contamination, peritonitis and a fatality. This is not only important in a colostomy but in any type of implantation of intestine within the abdominal wall, notably ileostomy for ulcerative colitis.

Posterior Resection.—The perineal approach to the removal of the rectum for cancer in the abdominoperineal operation is made easy or difficult by how well the abdominal portion has been done, how freely the rectum has been detached from the sacrum and the bladder or vagina from its lateral wall attachments. If the abdominal portion of the operation has been well done, at its completion and when the freed rectum is reduced into the pelvis and covered by its diaphragm of peritoneum, it will be attached only in front, in women, to the back of the vagina and the perineal muscles, and in men, to the prostate, urethra and to the levators laterally.

If the first portion of the operation has been so thoroughly completed that these attachments only remain, the perineal removal will occupy not more than fifteen or twenty minutes, depending on how much time is consumed in controlling the annoying small bleeders that are met here.

If the operation has been thoroughly completed from above, the *perineal approach will permit accurate visualization of all the anatomic structures in this field*—in the male, the attachment of the levators to the side, the vesicles, the prostate, the back of the bladder, the membranous urethra, the transverse perineal, and in the female one will be able to wipe off accurately from the anterior wall of the rectum the lax posterior vaginal wall, cut the levators on either side and demonstrate the perineal muscle (Fig 246).

We have over the years tried every type of position for this portion of the operation. We have now for several years employed the lateral position, with the patient on his left side, lower leg straight, the right leg pulled up, the buttocks sticking over the edge of the table, and an adhesive strap applied to the upper buttocks and then stuck on the table to keep the gluteal folds apart and expose the anal region (Fig 246, a). This is by far the easiest position in which to obtain

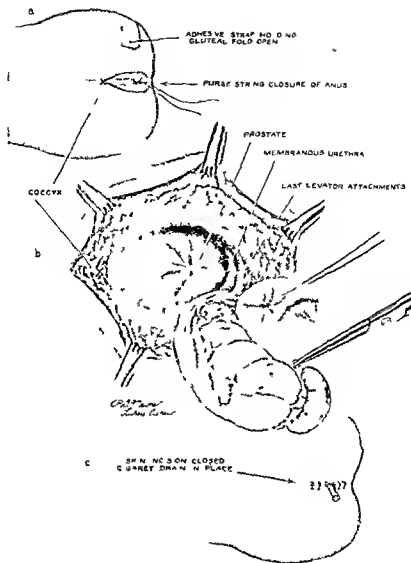


Fig. 246—*a*, The patient is in the lateral position and an adhesive strap is applied to the upper buttocks which will be stuck onto the table and thus pull the gluteal folds apart. This illustration also shows the black braided silk purse string stitch inserted about the anus and tied to close it with the ends left long to serve as a tractor.

The skin incision which is to surround the anus is shown by a shaded line from the tip of the coccyx to the midperineum.

b, The rectum has been turned out. Note the rubber covered end of the rectum which was found as soon as the incision was made in front of the coccyx which enters the pelvic cavity.

exposure of the entire perineum and pelvis and the one which produces the least undesirable strain upon the patient

Early in our experience we employed the Haynes or Buie position, with the patient face down, the table broken and the anus presenting directly, which is so useful in operations for fistulas or hemorrhoids. In operations often occupying a considerable period of time and with patients in whom because of their age and poor condition shock easily results, this is a very undesirable position.

It was demonstrated by Alfred H. Miller, an anesthetist in Providence, R. I., by tracings some time ago, that patients under any type of anesthesia which will produce abdominal relaxation, breathe almost entirely with their diaphragms. It is obvious, then, that when patients are placed upon their abdomen, particularly with the head down, the contents of the abdominal cavity not only gravitate against the diaphragm but that the weight of the body upon the lower ribs further hampers the excursion of this structure which takes place with this degree of anesthesia. Because of the drop in blood pressure which occurred in this position, we many years ago gave up this position to employ the lateral one previously described.

We have never been interested in undertaking operations upon the rectum on a patient in the lithotomy position. For us this is the most undesirable position of the three here mentioned, permitting as it does, the uterus and the vagina in the female and the bladder in the male to sag down, interfere with the exposure and make difficult the visualization posteriorly of the important anatomy in the pelvis.

With the patient in the lateral position and the rectum out the entire pelvis can be dried out, the ureters seen, the middle hemorrhoidal vessels inspected, the hollow of the sacrum examined for oozing veins, and any bleeding which has not been controlled from above visualized and controlled at this time.

Note that with the rectum turned down and the dissection done well from above the vesicles and prostate are exposed. The line indicates at the apex of the prostate the point where the membranous urethra may be felt with the catheter in it.

Note on the side the last levator attachments which when severed and the rectum pulled to the opposite side permits the severing of the levator attachments on the other side and the complete delivery of the rectum. Note the transverse perineal shown in the drawing just above the membranous urethra beneath which the membranous urethra disappears.

c. The wound is completely closed and a reasonably small cigaret drain is inserted never against the coccyx never at the lower part of the wound but always in the center of the wound to avoid osteomyelitis which occurs from contact with the coccyx. This also avoids in the male resting the drain against the often uncovered membranous urethra.

It is this closure which permits practically first intention healing in these patients and getting them out of bed at an early date and out of the hospital without a prolonged stay.

With the patient in this position and with this exposure, the heavy black silk stitch completely encircles the anal canal and is tied tightly (Fig 246, *a*). The ends are left long and an Ochsner clamp is applied to them in order to make traction upon it and pull the anus out, which makes it easy to surround the anal canal with a skin incision. The skin incision is started in front of the coccyx or a little above it, passes down on one side and on the other side of the anus in the female to a point midway between the anus and the back of the vagina, and in the male to a point midway between the anus and the back of the scrotum (Fig 246, *a*). The lateral skin incisions are deepened to the glutei, the ischioanal fascia is demonstrated, the perineum is dissected deeply until in the male the median tendon of the transverse perineal muscle is demonstrated in the female until the vagina has been dissected well up to the point where the posterior wall is attached to the front of the rectum.

With this amount of dissection completed, with the tip of the coccyx visualized, an incision is made boldly through the pelvic fascia until the opening enters the pelvis where the rectum has been freed from it. With a finger in the open pelvis it is hooked laterally, which brings into view the levators on either side. These are cut down on either side the rubber covered end of the rectum can now be visualized the rectum pulled out of the posterior wound and held forward which promptly allows visualization of the vesicles and prostate in the male and the back of the vagina in the female (Fig 246, *b*). In the male these structures are carefully wiped off until the apex of the prostate and the membranous urethra with its contained catheter can be seen or felt care being taken at this point as further dissection is carried on not to carry the dissection beneath the transverse perineal muscle (Fig 246, *b*).

In the female the vagina is gradually wiped down, the levators cut on either side until the rectum hangs laterally on either side by its last levator attachments.

With the rectum now held only by its lax levator attachments these are cut on one side the dissection being carefully carried in the male external to the transverse perineal muscle and in the female care being taken not to enter the attached vagina. One side of the rectum is dissected free, the rectum rolled to the other side and with scissors the levator attachments of the remaining side severed.

With the above steps completed, the rectum is now completely detached and all bleeders in the perineum and in the flaps of skin of the buttocks are carefully controlled. With a good light and with Deaver retractors, the hollow of the sacrum is visualized, any accumulated clot wiped out, the middle hemorrhoidal vessels demonstrated as tied and dry, and any oozing veins upon the hollow of the sacrum tied or controlled by electrocoagulation.

If the dissection from above has been adequately done, there will be very little oozing to control except that in the male which is found at the apex of the prostate and the lower portion of the vesicles. Thus will be of an oozing character and it will usually be necessary to control this by a gauze drain which is left in place postoperatively.

In the female there will often be oozing in the vaginal veins on the back of the vagina, which must likewise be controlled by the small cigaret drain which is left in place postoperatively.

With all oozing controlled, the gauze end of a small cigaret drain is now placed over the prostate in the male and over the perineum in the female.

I wish particularly to stress the fact that contrary to the custom in many places, the pelvic cavity is never packed with gauze. Every caution is exercised to control the bleeding high in the pelvis and on the back of the bladder or back of the uterus, but we feel very strongly that the practice which apparently has been established over the years of packing this large cavity with gauze is an undesirable one. It has been our experience that bleeding high in this cavity can always be accurately controlled either from above or at the second portion of the operation during the perineal removal, and that the small oozing on the back of the vagina in the female and the back of the prostate and vesicles in the male can always be controlled by a light gauze pack on the end of a cigaret drain.

It has been our experience in dealing with this considerable number now of cancers of the rectum (at least 1500), that if the small cigaret drain is removed on the fourth day, these posterior wounds, except for the hole left by the drain after its removal, heal by first intention. These patients are out of bed in from twelve to sixteen days. No longer do they have open discharging posterior wounds which prolong their stay in the hospital and complicate their recovery.

It is our opinion that closure of the posterior wound is dependent upon how soon the diaphragm of pelvic peritoneum descends to obliterate the space left by the removal of the rectum by becoming adherent to the pelvic wall.

If a large pack is placed in this cavity, it serves the purpose only of keeping the diaphragm of peritoneum elevated and of delaying time when this diaphragm descends to become adherent to the pelvic wall, and thus obliterate the cavity.

We have seen no disadvantage whatever of introducing only a small cigaret drain over the prostate in the male and over the back of the vagina in the female. We have, in fact, been impressed with the early closure and the clean posterior wounds which we have obtained by the employment of this procedure instead of large packs (Fig. 246, c).

These posterior cigaret drains are removed on the fourth day and the cavity remaining in the pelvis is irrigated duly with 1 per cent

iodine solution which has no particular advantage over any other mildly antiseptic solution but is employed largely for the mechanical purposes of washing out any accumulated clots or debris.

We are often asked how soon the colostomy is opened. One of the very great advantages of having a colostomy which is well established above the level of the skin is that it permits early and safe introduction of a catheter into the colostomy to decompress it should there be any gas distention.

We have no hesitancy in opening colostomies on the night of operation if the patients complain of cramps or if there is any undue distention of the loop. The wound is draped with gauze, sterile boric ointment strips are placed over the wound, and the Ochsner clamp on the end of the colostomy is released and moved over for a distance just sufficient to permit the introduction of a large catheter. The clamp is then approximated close to the catheter in order to make the bowel about the point where the catheter is introduced tight.

It is extremely undesirable to permit marked gas distention of the colostomy to exist over any period of time. This increases the pres-

. . .

goes with the distention of the colostomy loop in certain cases.

Should the colostomy not function adequately after the first four or five days it is explored with the finger for retained feces and irrigated with tap water to promote the discharge of feces and gas, care being taken to protect the wound with boric ointment strips.

Before the patient leaves the hospital if the colostomy loop is too long it is only occasionally necessary to sever it with the cautery without an anesthetic down to the point that it is of adequate length so that it projects well above the level of the skin.

There are a few rules regarding colostomy that should be considered in a general way without going in too specifically to every detail of colostomy management. One of the most important features of the management of colostomized patients is the maintenance of his morale. He starts with the idea that he is to be handicapped, that he must limit his business and social contacts and that he is a different individual from his fellow beings. This will be his attitude in spite of any encouragement his physician may have given him preoperatively. It is for this reason that maintenance of contact personally by telephone or by mail for the first four to six months in colostomized patients is so important.

It will take the colostomized patient four to six months to learn his constipating diet. It will take him this length of time to know the liberties he can take with his diet. It will take him this length of time when he has taken liberties with his diet and has had accidents such

as the escape of feces from his colostomy, to learn how to control it with boiled milk and paregoric. It will also take this length of time for his colostomy to shrink down, for the skin scar to contract around it until it is of such size that it admits only one index finger. When the colostomy has shrunk down to this size and is a rosette of skin raised above the edge of the wound, it is then in the final completed state for successful management.

I have been through experiences with so many of these patients who started out completely apprehensive as to their ability to manage their life with colostomies and have seen them gradually acquire the ability to constipate themselves and to manage their colostomies until the patient who was apprehensive at the beginning now volunteers the information that if there is someone in the same state he was in when he started, he would like to encourage him by telling him how much better he will be.

We teach patients upon whom a colostomy has been made, that with a colostomy they will substitute spaced irrigation of their remaining colon for voluntary defecation. It is true that we have a few patients who take no irrigations whatever, who are able to lean over a toilet and defecate as successfully as they could with their rectum. We are at a loss to explain how they can and why one can and another cannot. We do know that a very great majority of these patients must avoid discharge of feces by learning how to so constipate themselves that their bowels will move only when they irrigate them.

We tell these patients to select time for these irrigations as every other night or every third night, depending on what they choose. We tell them they must plan to do it in the evening because this will give them an adequate amount of time, and permit the remaining fluid in their colon to run out and so not soil their clothes. We tell them that no irrigation can be accomplished in any short period of time, that it will be necessary in many of the cases to introduce the fluid with a catheter and then wait for softening of the feces and for their discharge.

This can be done by several different means. Some patients have devised sleeves through which the feces are discharged. Others sit on a toilet with a sheeting apron below their abdomen and the sheeting put into the toilet bowl between their legs.

We discourage any wearing of colostomy bags on the part of the patient. If we have a patient who wears a colostomy bag, it is because he has not learned to so constipate himself that he can trust his colostomy not to discharge feces at unexpected times. We do not sell colostomy bags in the Clinic. If the patient has a colostomy bag we believe that he should come to us for further instruction on how to avoid its use.

Practically all of these patients wear only a pad of gauze, with

boric ointment spread over it so that it will not become adherent to the colostomy, and an elastic belt to hold it in place.

One should not fail to see these patients postoperatively for the first year once every three months so that they can discuss with their physician any of their difficulties with their colostomy and their diet and so that they can be observed as to their general physical state

CONCLUSIONS

The advantages of abdominoperineal operation as opposed to the operation retaining the sphincter are discussed

The indications for the two stage operation are discussed

The features involving limitation of operability are recorded

The type of anesthesia and the technical steps of abdominoperineal removal of cancer of the rectum are also discussed

Some of the features of the making and management of the colostomy are set down

The mortality in this operation over the past four years has been 38 per cent, with an operability rate of 83 per cent and with a five year nonrecurrence rate in the entire series of 50 per cent

While all of the above features are gratifying, it is to be noted that in the recording of symptoms for which the patient comes to the Clinic, it is these symptoms—the passage of blood, alteration in bowel function, change in character of the stools or abdominal pain—by which the diagnosis should have been made even in this group of cases with an operability rate of 83 per cent, much earlier than it has been

As a final warning I wish to state that there is still room for improvement based upon more prompt attention to the above set of symptoms in the group of cases here presented which seem so favorable. In addition to this, I would again, as I frequently have done, like to call attention to the fact that many polyps, adenomas and adenomas which give early sigmoidoscopic examinations admit their removal in many instances before these malignancies have occurred

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CARCINOMA OF THE COLON AND RECTUM: SITE OF GROWTH OF 1,457 LESIONS

EARL J. BOEHME AND PAUL J. HANSON

A REVIEW of the anatomical location of 1,457 cases of malignancy of the large bowel in which operation was performed at the Mayo Clinic from 1936 through 1944 brings emphasis again to the fact that 75 per cent of these lesions are found in the sigmoid, rectosigmoid

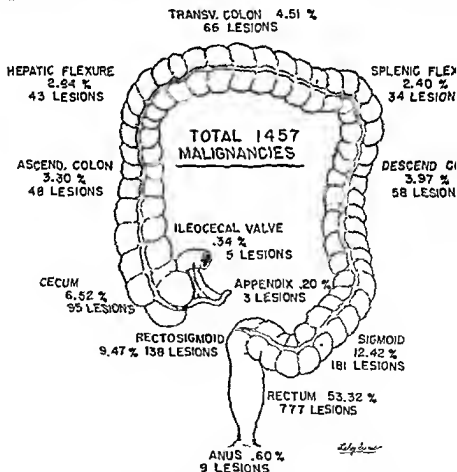


Fig. 247.—Anatomical location of the malignancies of the colon and rectum.

and rectum. As shown in the illustration (Fig. 247), the remainder of the lesions are almost equally distributed throughout the rest of the colon except for the cecum which has slightly more than 6 per cent of the total. This distribution of lesions varies only slightly from the series reported previously by Coffey, P. J., et al.

It is apparent then from this survey that nearly 70 per cent of the cancers of the colon can be palpated by digital examination or be seen through the sigmoidoscope. That these cancers not only in the left colon, but throughout the whole large bowel make their presence known by symptoms has been shown by Swinton and Higginbotham in this clinic. They reviewed the histories of 200 cases of cancer of the left colon and rectum and found "bloody stools" or altered bowel function in 82 per cent. Thus all patients who have these symptoms should have careful digital and sigmoidoscopic examination even when there is benign rectal disease which could account for the symptoms. In 100 cases of malignant disease of the right colon, Swinton found only 8 with bloody stool, but 87 per cent of the patients complained of abdominal cramps or an obstructive type of pain and 81 per cent complained of altered bowel function. These patients should be investigated by barium and air contrast enema.

Since the majority of these lesions can be diagnosed in the examining room, the patients must be educated to come early for study, and the physicians must carry out digital and proctoscopic examination in every case. In addition to the 70 per cent of malignant lesions which can be diagnosed if present, benign polyps and adenomas, occurring so frequently in the same region of the colon, can be found and removed since their predisposition to carcinoma is well known.

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THE DIAGNOSIS OF CARCINOMA OF THE COLON AND RECTUM

NEIL W SWINTON AND J LAWRENCE GILLESPIE

THE progress which has been made in the treatment of carcinoma of the colon and rectum in the last decade has been one of the most gratifying in any field of surgery. More accurate diagnostic methods, improvements in the preoperative preparation of these patients, better anesthesia, more experience in the actual surgical removal of these lesions, the use of whole blood, plasma, proteins, chemotherapy and the improved postoperative care of these patients have resulted in a resectability rate of 85 per cent and a five-year survival rate of 50 per cent in this Clinic.

This improved prognosis for patients with malignant disease of the large bowel has not been accompanied in recent years, however, by any appreciable lessening of the time interval between the onset of symptoms and the establishment of the diagnosis of cancer. It is common to encounter patients with gastrointestinal complaints who have been under the care of a physician for some time and who on digital examination of the rectum are found to have an advanced malignancy, a digital examination not having been done previously. It is also not uncommon to examine patients with colon and rectal complaints who have had one or more barium enema roentgenologic studies of the colon which have been reported as negative and to find an easily visualized advanced malignant tumor of the rectum or lower sigmoid by sigmoidoscopic examination.

The average time interval from the onset of symptoms to the time of operation for malignancy has been, for several years in our experience, nine months. In order to reduce this time interval, the following policies should be adopted by all physicians who come in contact with this disease: (1) Increasing attention must be given to the symptomatology of carcinoma of the colon and rectum. (2) The differential diagnosis of cancer of the colon and rectum from nonmalignant lesions must be appreciated. (3) The indications for digital examination of the rectum, sigmoidoscopic study of the rectum and lower sigmoid, barium enema and contrast air radiograms of the rectum and colon must be understood. (4) A constant search for and the removal of premalignant lesions of the bowel must be undertaken. (5) An accurate diagnosis of cancer must be made at the earliest possible time.

SYMPTOMATOLOGY

It is true that there are no symptoms or groups of symptoms which one might designate as pathognomonic of malignant disease of the large bowel, yet studies of these patients reveal that there are symptoms which accompany the disease sufficiently often to demand careful investigation.

Right Colon—The primary function of the right half of the colon is absorptive in nature. Symptoms arising from lesions in this position of the bowel usually result from changes in physiology. The lumen of the right half of the colon is larger than that of the left. Tumors in this location tend to be large ulcerating lesions on the lateral wall of the bowel, not encircling the lumen as they so commonly do on the left side of the colon. Obstructive symptoms, therefore, are much less commonly seen with lesions of the right side than with lesions of the left side.

In a series¹ of 100 cases of cancer of the right colon reported from this Clinic in 1938, 87 per cent of the patients complained of abdominal cramps, indigestion or pain, Chamberlin,² in 1941, reporting a series of malignancies confined to the cecum, mentioned pain in the right lower quadrant, anemia, weakness and fatigue, and a palpable tumor, in the order named, as the predominant symptoms of malignant tumor confined to this locality. In this latter series, 66 per cent were found to have a hemoglobin of less than 70 per cent at the time

	anemia,
	1 patients
	d 14 per

cent in his series. The exact mechanism of blood loss due to malignancy of the right colon is not completely understood. Several observers believe it is the result of a toxic process. However, with the high incidence of anemia so commonly found in this condition, cancer of the right colon must always be considered when any unexplained anemia is present.

Rankin has reported that 10 per cent of these patients may have a palpable tumor in the right lower quadrant without other symptoms suggestive of bowel malignancy. Seven of our patients in the group of 100 came to us for explanation of a right sided tumor mass which had been found on a routine physical examination.

Alternating constipation and diarrhea has rarely been noted in our experience, although in our series previously mentioned, 30 patients with malignant tumor of the right colon mentioned diarrhea or frequent loose stools, and 16 complained of increasing constipation.

Left Colon—Obstructive symptoms predominate in patients with carcinoma of the left colon. Tumors in this area are usually encircling the lumen is narrower than that of the right colon and the stool is firm, so that obstructive symptoms and cramps usually appear early.

in the disease. Although an increasing constipation is common, complete obstruction is rare.

Bloody stools or other abnormalities of the stool have been noted in approximately one half of our cases of left-sided tumor. An occasional palpable tumor will be found. Frequent loose stools or an actual diarrhea has been found in 30 per cent of these patients, and 80 per cent of patients with malignant disease of the left colon complain of some change in their normal bowel habit.

Rectum—In considering lesions of the rectum, it must be remembered that the majority of these tumors are found in the ampulla where the lumen of the bowel is large and, consequently, obstructive symptoms occur only in the late stages of the disease. The predominant symptom is an abnormal stool. Eighty six per cent of our patients complained of some abnormality of their stools at the time of examination. The presence of blood, pus or mucus and, less commonly, a change in the caliber of the stool are the usual complaints. A large group complained of increasing constipation and less commonly, diarrhea is noted. Rectal pain and tenesmus are common when the lesion is found near the anal outlet. Urinary symptoms occasionally occur and usually indicate involvement of the bladder or urethra.

Although patients with large bowel malignancy present a wide variety of symptoms, these symptoms may be grouped under the following headings: (1) Any abnormality of the stool. This includes the presence of blood, pus or mucus, or any change in the caliber of the stool. (2) Any change in the normal bowel habit of an individual. This may mean an increasing or decreasing constipation, diarrhea or frequent loose stools. It means any change from what has been for that individual a normal bowel function. (3) Any unexplained abdominal pain, cramps, indigestion or feeling of fullness. (4) An unexplained abdominal tumor or anemia.

It would seem obvious that if all patients presenting any of these symptoms were given a careful and complete examination of the rectum and colon at the time they were examined by the first physician to see them this long time interval, which so frequently occurs, between the onset of symptoms and the surgical removal of these tumors, could be reduced. This examination should include, in the order named, a careful history and physical examination of the patient, digital examination of the rectum, proctoscopic and sigmoidoscopic examination of the rectum, rectosigmoid and lower sigmoid and radiographic studies of the colon.

DIFFERENTIAL DIAGNOSIS

Approximately 70 per cent of the surgical procedures on the large bowel performed in this Clinic are for malignancy, yet it must be recognized that other lesions than cancer may require surgical inter-

in this region. The most common of these are chronic, stenosing regional enteritis, diverticulosis, diverticulitis, tuberculosis of the ileocecal region, benign polyps and less commonly, volvulus, sarcoma, nonspecific granulomas and benign tumors other than polyps. In the rectum, hemorrhoids, abscesses and other anorectal conditions must always be considered in the differential diagnosis of malignant disease. In many instances the differentiation of carcinoma from these other possibilities may be difficult, yet it must always be remembered that the majority of surgical lesions in the colon are malignant and when cancer of the large bowel is suspected the lesion should be regarded as such until proven otherwise.



Fig 248



Fig 249

Fig 248—Enterolithiasis of the ascending colon with ulceration and obstruction.
 Fig 249—Unusual traumatic herniation of diaphragm with splenic flexure of colon in the left anterior chest.

It is not the purpose in this article to review in detail the symptomatology and pathology of all the conditions that may be mistaken for malignancy of the colon and rectum. Lesions which are palpable to the examining finger or can be removed for pathologic examination through the 10 inch sigmoidoscope ordinarily present few difficulties in establishing an accurate diagnosis. Lesions not visualized by instrumentation must be distinguished by radiographic means (Figs 248 to 254). The accuracy of diagnosis by roentgenograms of those lesions which cause a defect in the lumen of the bowel, such as diverticulitis and diverticulosis, tuberculosis, ulcerative colitis and

cancer, is high. Benign polyps, on the other hand, do not cause deformity of the lumen and when beyond the reach of the sigmoidoscope are frequently not detected.

In the differential diagnosis of organic disease of the colon and sigmoid, the Department of Radiology of the Clinic has established the following brief criteria for diagnosis:

1 *Chronic stenosing regional enteritis* is best demonstrated by serial films of the small bowel (Figs 250 and 251). The most characteristic roentgenographic sign attributed to this lesion is the "string sign" which shows the barium passing through the small bowel in a string like pattern. The patient may have retention in the proximal loop with the oral meal. There may also be areas where the bowel



Fig 250



Fig 251

Fig 250—Regional enteritis involving the distal jejunum and ileum. Note string like pattern of small bowel.

Fig 251—Typical regional or terminal ileitis.

lumen is narrowed and irregular, alternating with areas of normal bowel, and therefore roentgenologic study after a barium enema should always be done in addition to the serial films of the small intestine.

2 *Tuberculosis of the ileocecal region* may be demonstrated both by the oral meal and by the barium enema. Irritability or deformity of the cecum and a variable portion of the terminal ileum is usually seen. With the oral meal there may be a filling of the segment distal and proximal to the lesion on the six hour and twenty four hour examination, with the involved area showing no barium. When an enema is given it can be seen on fluoroscopy that the cecum contracts and empties before complete filling is obtained. In the hyperplastic type, a mass is outlined which is often indistinguishable from carcinoma in this region. There is normally localized tenderness when a

mass is palpable. Foreshortening of the cecum is an important finding in the ulcerative type of tuberculosis.

3 *Diverticulosis* These lesions are most commonly located in the sigmoid and descending colon but may involve any portion of the gastrointestinal tract. They will be demonstrated on the twenty-four hour examination after the oral administration of barium or on the postevacuation film of a barium enema. They are seen as small outpouchings of the mucosa and submucosa, and may be single or multiple. A small diverticulum is usually seen as a "bud like" (or funnel) shadow with a rounded distal end, and projects outside of the lumen. If a large diverticulum containing a fecolith is present the fecolith is outlined by the barium giving a "ring like" shadow. Unless there



Fig 252



Fig 253

Fig 252—Polypoid tumor of the colon after an ordinary barium enema.

Fig 253—Same case as shown in Figure 252. After the contrast air technique.

is an associated inflammatory lesion there is no tenderness on palpation. This is important in the differential diagnosis between diverticulosis and diverticulitis.

4 *Diverticulitis* This is best demonstrated by a barium enema and shows narrowing of the lumen and in some instances complete obstruction. This narrowing shows irregular "saw tooth" margins. There is pain and tenderness on palpation.

5 *Spastic colon* In differentiating a spastic colon or functional colonic disease the roentgenogram is useful in distinguishing organic lesions before treatment is begun. The reproduction of the pain of which the patient complains is considered an important adjunct to the history and clinical examination.

6 *Polyps and polyposis* To demonstrate polyps it is necessary to have the colon well prepared and free of fecal material before a

barium enema is given as fecal material closely simulates polyps. On the postevacuation film the barium is seen to cling to the mucosa (Fig. 252). The polyps are shown in the interrupted mucosal pattern as mottled, rounded shadows of diminished density. The best method to demonstrate these lesions is the contrast air enema, taking stereoscopic films (Fig. 253). The polyps will be seen as masses faintly outlined by barium projecting into the lumen.

7. *Ulcerative colitis.* This is best demonstrated by the barium enema. There is irritability of the involved areas with smoothness of the walls and absence of haustra. There may be low, fine indentations along the margins due to ulcerations between which small polypoid formations frequently occur, giving a fuzzy appearance to the mucosa. There is also edema of the serosa of the colon. When ad-



Fig. 254



Fig. 255.

Fig. 254—Advanced ulcerative colitis. Colon appears rigid and tubular.
Fig. 255—Typical carcinoma of the transverse colon. Note irregular and jagged margins

vanced fibrosis and thickening occur, the colon appears rigid and tubular (Fig. 254), with a decrease in the size of the colon because of shortening and narrowing of the lumen. Frequently thickening of the wall of the bowel may be found owing to an associated edema.

8. *Carcinoma of the cecum* is best demonstrated by a barium enema. A filling defect of the cecum, with some irregularity, is ordinarily found which is not as marked as in tuberculosis of this region.

9. *Carcinoma of the sigmoid* should always be demonstrated by a barium enema and not by an oral meal because of the danger of precipitating an obstruction. The findings may be any one of the following three: (a) Complete obstruction may result from blocking by materials from above with a "blunted" or "hooked head" of the barium enema. (b) The lesion may show an annular or "napkin-ring" defect, about 3 to 5 cm. in length, with no expansion on pressure from the

fluid. The bowel on either side of this defect appears to be irritable. (c) There may be a fungating type of lesion which invades the lumen from one side, giving a subtraction or intraluminal defect, with irregular and jagged margins (Fig. 255).

In distinguishing diverticulitis from carcinoma of the sigmoid, it is usually of the

carcinoma the margins are quite irregular, destroying the mucosal markings and producing a smooth inner surface. Again, it will be seen that in diverticulitis the lumen changes in width with pressure of the fluid, provided there is not complete obstruction, while in carcinoma the lumen remains unchanged and rigid. Another point in distinguishing these two lesions is that in diverticulitis the adjacent mucosa is usually involved for a longer distance than that seen with carcinoma, in which the mucosa is normal proximal and distal to the neoplasm.

10. Carcinoma of the rectum. The roentgenologic demonstration of lesions of the rectum is secondary to palpation and direct visualization in view of their accessibility to both these examinations. We do not depend on the roentgenogram for diagnosis of lesions in this region. If such a lesion is to be examined roentgenologically, the examination should be limited to a barium enema. It is useful only in advanced cases of malignant disease to demonstrate the upper limits of the tumor.

PREMALIGNANT LESIONS OF THE BOWEL—POLYPS

In addition to this consideration of other surgical lesions of the colon and rectum which must be distinguished from cancer in this region, emphasis must be given to the relationship of benign, mucosal polyps of this area to cancer. This relationship has been well established.⁸ It is our belief that polyps of this nature are definite tumors and should be considered as definite premalignant lesions. Certainly, the ideal approach to cancer of the colon and rectum would be to detect and remove all such tumors before they become malignant. Unfortunately, however, only a small number of these benign tumors produces symptoms before they undergo malignant change. Brust has reported that only 20 per cent of his patients with benign polyps presented symptoms referable to the tumor. Fifty per cent of our patients who have had benign mucosal tumors were investigated because of bleeding, but in many of these the bleeding was found to be due to other causes. There are, however, certain facts concerning benign rectal and colon polyps which are recognized.⁸ (1) The incidence of polypoid disease in the colon and rectum is much more common than has previously been recognized. Various observers^{3, 8} have reported an incidence of from 2 to 6 per cent existing in the adult population.

(2) These polyps are not the result of a diffuse inflammatory process but are true tumors. (3) Approximately one third of patients with polyps have multiple tumors. (4) They may occur at any age and have an equal distribution in the sexes.

In addition to the difficulty in determining the indications for examination of patients with polyps because of the paucity of symptoms, radiologic studies of the colon, that is barium enema and contrast air radiograph, have not been entirely satisfactory. In the autopsy series reported in the literature there has been a fairly even distribution of the polyps throughout the colon and rectum, yet clinically 70 per cent of the polyps discovered have been within reach of the 10-inch sigmoidoscope. Since 70 per cent of malignancies of the colon and rectum occur within reach of this same instrument, this location represents the more important site. The fact that there may be a relatively even distribution of benign polyps throughout the colon and rectum and yet 70 per cent of all malignancies are found in the low sigmoid, rectosigmoid and rectum indicates that there are other factors than the mere presence of a mucosal polyp in the development of malignant disease of the colon. This factor is not thoroughly understood but may be related to the increasing trauma of the solidarity of the fecal stream in this region.

If the ideal approach to cancer of the colon and rectum is to be obtained, not only should those patients who present symptoms suggestive of cancer in this region be submitted to sigmoidoscopic examination, but because of the frequency and the known relationship of benign mucosal polyps, so few of which present symptoms before they become malignant, sigmoidoscopic examination should be a part of every complete physical examination.

There has been a tendency to reserve for the specialist sigmoidoscopic and proctoscopic examinations of the lower bowel. This extreme specialization is not necessary. A sigmoidoscope should be as much a part of the armamentarium of the general practitioner of medicine as a stethoscope. The cost of this instrument is relatively small and very little experience is required to use it. It is true that complicated problems of diagnosis and management may be encountered which will require the judgment of someone with special experience in this field, but all physicians should be able to recognize the normal and the abnormal in the lower 10 inches of large bowel, which in most instances can be reached without difficulty and without danger to the patient.

DIAGNOSIS OF MALIGNANT DISEASE

To establish the diagnosis of cancer, a digital examination of the rectum should always be done first. Palpation of a tumor with a firm, fixed, indurated base or border is pathognomonic of malignancy

Hemorrhoids, abscesses and fistulas can be distinguished in this manner by an experienced observer. Polypoid tumors will be found on occasion which on biopsy will be shown to be benign, but when a firm indurated base is palpated, repeated biopsy specimens should be taken until tissue is removed from the base, which will invariably demonstrate cancer. On the other hand, large polypoid tumors may be encountered in the ampulla of the rectum which do not present a fixed, indurated base which will be found to be benign following the removal of the entire tumor and examination of all sections. It must be remembered, as we have previously pointed out, that malignant disease may begin in any portion of a mucosal polyp, and malignancy is not ruled out until all sections of the tumor have been examined histologically.

Probably the most difficult problem with which we have to deal is the differential diagnosis of cancer in those patients with a known diverticulitis in whom it is suspected that there may be superimposed or associated malignancy. Frequently it will not be possible to pass the instrument into or beyond the area of inflammation, so that even though the lesion may be in the rectosigmoid, direct visualization of the tumor cannot be obtained. In these patients considerable reliance must be made on the radiographic study. It has been our experience, however, that occasionally it will be necessary to submit these patients to laparotomy so that the tumors can be directly examined from above and bimanual palpation through the rectum and through the abdomen carried out, and a final decision made only at that time. We have had the experience also of performing a colostomy above such an obstructing lesion, and have been able to establish the diagnosis by passing a sigmoidoscope down to the lesion from above through the open colostomy and visualizing an area which it was not possible to see from below.

SUMMARY

In an attempt to establish earlier diagnoses of malignant disease in the colon and rectum the following policies are suggested: increasing attention should be given to the symptomatology of carcinoma of the colon and rectum. In general symptomatology of large bowel malignancy may be grouped under the following headings: (1) any abnormality of the stool, (2) any change in the normal bowel habit of an individual, (3) any unexplained abdominal pain, cramps, indigestion or feeling of fullness, (4) any unexplained abdominal tumor or anemia.

A brief discussion is given of the more common surgical conditions of the colon which may be confused with malignant disease. These are chronic, stenosing regional enteritis, diverticulosis, diverticulitis, tuberculosis of the ileocecal region, volvulus, sarcoma, nonspecific granu-

lomas, mucosal polyps and other benign tumors, hemorrhoids, abscesses and other anorectal conditions

The importance of the relationship of benign mucosal polyps to malignancy in this region is emphasized. The frequency, distribution and prucity of symptoms are discussed.

It is shown that if the ideal approach to cancer of the rectum and colon is to be obtained not only should those patients with symptoms suggestive of cancer be submitted to a complete rectal and colon examination but a digital and sigmoidoscopic examination of the lower bowel should be a part of every complete general examination.

The importance of palpation of suspected malignant tumors and the histologic examination of all portions of rectal and colon tumors in the accurate establishment of the diagnosis of cancer is discussed.

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CANCER OF THE RECTUM

A DISCUSSION OF PREOPERATIVE PREPARATION, POSTOPERATIVE COMPLICATIONS AND COLOSTOMY MANAGEMENT

EARL J BOEHME AND RICHARD B CATTELL

For the past seventeen years in this Clinic we have been particularly interested in the management of patients with permanent colostomy. We feel that it is the responsibility of the surgeon undertaking abdominoperineal resection to guide and follow the patient indefinitely. From time to time we have published reports¹⁻⁴ in the hope of obtaining a wider acceptance of colostomy since we feel it is necessary for the radical cure of cancer of the rectum and rectosigmoid. Successful experience with hundreds of colostomies here in the Clinic has proved that the employment of a definite plan of management has facilitated the task of the surgeon, the nurses and the patient and it has aided in the early detection of complications or significant deviations from the normal postoperative course.

PREOPERATIVE PREPARATION OF THE PATIENT

If there is a lapse in the time between the decision to operate on the patient and entry into the hospital the patient is given a very high caloric, high vitamin and high protein diet to follow in the interim. Although serum proteins are not significantly lowered by lesions so low in the intestinal tract unless they are causing obstructive symptoms or cachexia, it is well to be certain that the patient's nutritional level is at its best. We have recently instructed the patient to take 9 to 12 gm. of sulfasuxidine daily in divided doses starting four or five days before the patient enters the hospital.

On admission to the hospital laboratory studies include a complete blood count, estimation of the nonprotein nitrogen, plasma chloride determination, serum protein level, blood grouping and urinalysis. The physical examination of the patient must focus special attention on the abdomen to determine whether there is any evidence of intestinal distention before any order is written to empty the bowel with a saline purgative. If distention is present an immediate roentgenologic study must include a flat plate and occasionally a lateral plate of the abdomen. If the patient exhibits moderate distention of the colon but is passing some stool and gas by rectum it may be possible to prepare and decompress the bowel cautiously with high colonic irrigations and small doses of magnesium sulfate. If the dis-

tention is severe, it will be mostly in the colon, and operative decompression by either cecostomy or a first-stage Lahey operation must be carried out. If, in addition, small bowel distention is shown on the film, a Miller-Abbott tube should be introduced with a stilet under fluoroscopic vision and decompression carried out to the distal ileum before any operation is performed to decompress the colon.

Patients with nonobstructing lesions are given $1\frac{1}{2}$ or 2 ounces of 50 per cent magnesium sulfate solution. Following evacuation of the bowel the colon is irrigated twice daily for two days prior to operation. The sulfasuxidine is also continued until the day of operation. A properly prepared colon will be contracted, empty, and easy to handle at operation. The final preparation for operation is the insertion of an indwelling bladder catheter.

Whether the patient should be told before operation that a colostomy is necessary is a question that should be decided by the surgeon and cannot be answered without careful consideration of the individual patient. Until one has a large experience with this type of case, the first impulse is to tell the patient with care and patience that a colostomy will be necessary. In many cases this will be a satisfactory approach, but we have all seen patients who refuse operation at the mere suggestion of the possibility of a colostomy. They have a very distorted view of colostomy and imagine that in the future their lives will be anything but happy. Even the frank statement to the patient that operation is necessary to save his or her life may not alter the decision against operation. These patients return many months later, obstructed, in severe pain, and hopelessly inoperable. They then may state that in retrospect they wish the original discussion about operation had been omitted entirely and the choice of procedure left to the judgment of the surgeon.

There is a small percentage of patients who bravely insist on being told all of the details of the diagnosis and contemplated procedure. Often this over-protestation of bravery masks feelings which are much the opposite. They are likely to stand the vicissitudes of the first two weeks very poorly, and not infrequently it is found that they are having their irrigations done by the visiting nurse six months after operation. There are also a few stolid persons who want to know the truth and accept it and make the best of it. They realize that the operation is necessary to save their lives, and they are usually grateful and adjust easily to the colostomy regimen.

Experience proves that there is much to be said in favor of tactfully avoiding any discussion of colostomy with the patient before operation. Any patient who has had bloody stools, increasing pain and constipation which could not be relieved by simple measures must have given some thought to the possibility of an operation which might deprive him of his rectum. The referring physician may have

suggested this possibility to him. A number of patients purposely avoid any discussion or questions about the approaching operation. They may fear the worst but secretly hope that it will not be true. All of the patients should understand that operation is imperative, that the cure of the disease is the primary objective, and that what is to be done must be left to the judgment of the surgeon.

After operation it is best to avoid any discussion of the colostomy until the patient begins to ask questions about it. Often the patient does not comprehend the colostomy for a week or ten days. Realization of its existence may depress him, but it is best to have such emotion with the operation a thing of the past than to have it before operation and precipitate a decision against having the surgical procedure done. The depressed state will pass gradually, and the patient will become more optimistic, regain his desire to live and make the best of what at the time seems like an unsurmountable difficulty. Nearly all when seen periodically after leaving the hospital accept their colostomy and are proud of their ability to manage it well and to carry on a normal life.

POSTOPERATIVE CARE

The details of abdominoperineal resection are discussed elsewhere in this volume. It is important to say a word about the simple requirements of a good colostomy. After operation it should project at least $1\frac{1}{2}$ inches above the skin level. It should be located in the left midrectus and be 1 to 2 inches below the level of the umbilicus. The patient must be assured, however, that the frightening projection of bowel and fat appendages will recede and in a few months leave only a pink ring of mucosa raised no more than a quarter of an inch above the skin level. This gradual shrinkage of the colostomy does much to elevate the morale of the patient.

The immediate postoperative care is similar to that following other major operations. Shock is rarely a factor if the operation has not been unduly prolonged. Intravenous fluids with glucose, saline, whole blood when indicated, vitamin C and B complex, and in certain cases amino acids, are given for the first two or three days after operation. Vitamins are continued throughout the hospital stay. Transfusions are repeated when indicated. The indwelling bladder catheter is connected to a system of closed drainage so that the bladder may be irrigated daily and an accurate measurement of the output can be obtained. On the day of operation the posterior wound dressing must be inspected for bleeding. In the evening the colostomy should be inspected by separating the dressing down to, but *not* disturbing the clamp or gauze about the colostomy. This inspection should be done again the next morning and evening. Any compromise in circulation will be manifest by cyanosis and discoloration of the visible part of the bowel or its mesentery.

On the evening of the first postoperative day the colostomy should be decompressed. Again only the dressing down to the clamp on the bowel is disturbed. The clamp is removed and the bowel edges are gently pulled apart. A well lubricated soft, number 14 French catheter is then inserted into the colostomy. The dressing is then changed and the catheter is secured around the bowel. If there is distress on the second or third day, 1 ounce of water may be injected into the catheter, but irrigation should not be done.

On the fourth postoperative day the dressing about the colostomy is separated down to the skin for the first time. The clamp is removed and the catheter is withdrawn. No matter how soiled the gauze dressing adjacent to the exteriorized bowel, it should not be removed before the fourth day since it is one of the factors in preventing retraction of the colostomy. The chief support for the first few days is the inclusion of two of the appendices epiploicae to the peritoneum closure. In four days the natural adhesions between the bowel and the subcutaneous tissue will prevent retraction. The posterior pack is removed at the same time, usually without discomfort. If the pack is large and the patient experiences a significant amount of pain, it is removed the next day under light inhalation anesthesia. This can be done in the room and vinyl ether or intravenous sodium pentothal is used.

Care of the skin after the first dressing consists only of simple soap and water cleansing whenever it is soiled. The sutures are covered by a loose gauze dressing. Vaseline strips, salves, pastes, powders, and so forth, are absolutely contraindicated. The skin about a colostomy will not become macerated or irritated unless some of these medicinal preparations are used.

On the fifth postoperative day the patient is given 2 drams of milk of magnesia every hour for five hours. This will usually produce one or more small movements in the next twenty four hours. The first colostomy irrigation should be done on the seventh day. A 1 or 2 quart warm water or soapy water enema is given through a small catheter inserted as far as possible into the bowel. Irrigations should then be given every two days while the patient is in the hospital. On the sixth day the posterior irrigations should be started and done twice daily by inserting a soft catheter well up into the posterior space, irrigating with a few ounces of the solution. This solution for irrigation is made by adding 1 dram of 3.5 per cent iodine solution to a quart of sterile water. If the drainage from the posterior wound is purulent, a 0.8 per cent solution of sulfanilamide is used. After the patient is ambulatory, hot sitz baths should be taken twice daily until all drainage ceases.

On the seventh postoperative day the skin sutures of the posterior

and abdominal wounds are removed. The retention sutures of the abdominal wound must remain until the twelfth to the fourteenth day. On the seventh day the bladder catheter is also removed unless the patient has a history suggesting prostatic obstruction. (If so, the catheter is kept in for ten to twelve days.) In six hours the patient is catheterized after voiding to determine the amount of residual urine. If after several six hour tests the residual does not fall below 3 ounces the patient is placed on catheter drainage again for three or four days and rechecked again. The patients may be out of bed on the thirteenth postoperative day.

MANAGEMENT OF COLOSTOMY

As a result of seeing these patients at frequent intervals after they leave the hospital we can state that with a definite plan of training the presence of a colostomy can be made a tolerable situation. Detailed printed instructions for the care of the colostomy and the diet are given the patient for study and discussion. Before leaving the hospital the patient should do one or more of the colostomy irrigations under supervision of the nurse. It is a good idea to have every patient put on a rubber finger cot or glove and insert a finger into the colostomy. This will do much to allay the patients' fear of its being very fragile or extremely sensitive to touch. This familiarity will give them courage to insert a finger when at home if it is necessary to break up a small impaction. Dilution will help to avoid skin contraction about the orifice.

Colostomy bags or other apparatus are not worn. The most satisfactory means of covering the colostomy is a small gauze dressing or absorbent paper held in place with a 6 inch wide elastic belt. These can be purchased in any athletic supply house or they can be made at home. A 9 inch square of "oiled silk" cloth is placed over the pad to avoid soiling the belt. For female patients, any girdle or corset will usually serve adequately. The dressing will need changing two or three times in twenty four hours. In well managed colostomies it will be soiled only by drainage of mucus from the exposed mucosa of the bowel. Occasionally because of mechanical irritation there will be bleeding from the colostomy edge. The prevention of unexpected fecal drainage will be discussed under dietary management later in this paper. It must be mentioned that some patients do have audible passage of gas from the colostomy, but this too can be avoided for the most part by regulation of the diet. Colostomy plugs are obtainable commercially if desired but are rarely necessary in our experience.

At home the patient uses simple irrigation equipment consisting of a 2 quart enema can or bag, a 4 foot rubber hose, a shut off clamp, a glass adapter, and a number 22 French rubber catheter. The irrigation should be taken in the evening to catch any additional watery dis-

charge during the night. The irrigation may be taken in the sitting position or when lying down. A rubber apron is valuable to cover the lap and legs. Two quarts of warm water or soapy water are injected slowly after inserting the catheter to its full length if possible. If cramping occurs, flow should be interrupted temporarily. It may be necessary to compress the lumen of the bowel with the fingers to prevent back flow while injecting the fluid. If satisfactory evacuation

DIET FOR COLOSTOMY PATIENTS

Colostomy Diet 1 (Used in hospital while first gaining control and at any time later when loose movements occur)

Breakfast

Large portion of cream of wheat with boiled milk, sugar if desired, two hard boiled eggs, dry toast, one glass of boiled milk

Lunch

Creamed soups (creamed lettuce soup three or four times a week), creamed fish or meat, baked or mashed potato, boiled rice or custard

Dinner

Meat or fish, creamed whenever possible, escalloped vegetable—no spinach or carrots, soft pudding, custard or junket

Colostomy Diet 2 (Used after gaining control in the hospital [2 weeks] and continued for two months at home)

Cream of wheat, puffed wheat or puffed rice

Eggs, boiled, poached, baked or scrambled

Oven-broiled bacon

White bread, plain or toasted

Plain white crackers or saltines

Butter, cheese, milk, tea, coffee, cocoa

Boiled rice, baked macaroni or spaghetti

Baked custards

Soups of all kinds except tomato or corn

Potato, baked, mashed or riced

Roast beef, lamb or chicken

Broiled steak or lamb chop

Fish, broiled, boiled or creamed

Sponge or angel cake

Colostomy Diet 3 (Added to Diet 2 after two months if control is still effective)

Raw lettuce and celery

Cooked string beans, peas, carrots, beets, winter squash, cauliflower, asparagus

Cooked fruits

Orange juice

Avoid green corn, baked beans and fried foods

does not occur, a second 2 quart irrigation should be given. Changing position and gentle pressure on the abdominal wall will assist the emptying. The contents of the bowel can be collected into a basin or other container held against the abdominal wall below the colostomy. For the more fastidious patients there is an apparatus which consists of a dome held over the colostomy by a belt around the waist. The dome has a large drainage hole at the bottom and a large rubber tube

and abdominal wounds are removed. The retention sutures of the abdominal wound must remain until the twelfth to the fourteenth day. On the seventh day the bladder catheter is also removed unless the patient has a history suggesting prostatic obstruction. (If so the catheter is kept in for ten to twelve days.) In six hours the patient is catheterized after voiding to determine the amount of residual urine. If after several six hour tests the residual does not fall below 3 ounces the patient is placed on catheter drainage again for three or four days and rechecked again. The patients may be out of bed on the thirteenth postoperative day.

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sufficiently to keep the bronchioles clear. Violent coughing, an intra tracheal catheter, or in stubborn cases, suction bronchoscopy will remove these plugs and improvement will be dramatic. When the atelectasis is in the bases, one must be certain that there is no intestinal distention or massive dilatation and distention of the stomach pushing the diaphragm upward. Decompression of the stomach by intra gastric suction is usually sufficient to correct this condition if it is the cause. Any patient who exhibits atelectasis should be given penicillin immediately to preclude the development of pneumonia or other pulmonary complications. Deep breathing, frequent change of position, and voluntary coughing will do much to prevent this complication. It is obvious, therefore, that only enough morphine should be given to maintain reasonable comfort after operation. Large doses depress the cough reflex and mucus collects to obstruct the bronchioles. Patients who smoke and cough habitually should be allowed to smoke soon after operation if they desire.

Signs of *intestinal obstruction* may vary from simple obstipation to distention, crampy colicky pains, and vomiting. Prompt recognition and institution of proper treatment are imperative. Mechanical obstructions may be due to the attachment of a loop of ileum to the peritoneal diaphragm by plastic adhesions. Distention without colic, but with nausea, hiccups, and belching will usually reveal an ileus secondary to some intra abdominal inflammation. These patients should be taken to the x ray department where a flat plate of the abdomen can be taken for accurate confirmation of the diagnosis. If the distention of the small bowel is confirmed, and the symptoms do not indicate a mechanical obstruction with recurrent severe crampy pains and peristaltic rushes that would require immediate surgical intervention, a Miller Abbott tube should be introduced with a stilet and intestinal decompression carried out as rapidly as possible. Plasma and intravenous glucose and saline solution are important in obstructions with distention. Sulfonamides and penicillin should be added to the therapy. The differentiation between a partial mechanical obstruction and obstruction with ileus from an adjacent inflammatory process is difficult to make, but fortunately these complications are uncommon.

Difficulty in emptying the bladder is the most frequent postoperative urinary complication. It results from the changed position of the bladder which falls back into the pelvis, having lost its posterior support. There is disturbance of the nerve pathways to the bladder because of the extensive pelvic dissection necessary, particularly in the large growths. Ewert reviewed nearly 1000 abdominoperineal resections done in this Clinic and found an incidence of obstructive manifestations in 14 per cent of the males and in 4 per cent of the females. In 80 per cent of the group of males a previous history of some urinary

tive symptoms was elicited Urologic consultation should not be delayed if after removal of the indwelling catheter for twenty four hours there is a residual of more than 3 ounces The patient should be placed on catheter drainage and irrigations again for four days after which the residual urine is checked In this series reported by Ewert it was necessary to do a transurethral resection in two thirds of the males exhibiting the obstructive symptoms There was no mortality from this added procedure In the patients over 55 years of age bilateral vasectomy is done at the same operation Operative intervention has not been necessary in any of the female patients although catheter drainage up to eight weeks has been necessary in a few refractory cases

Thrombo embolic disease is of significant frequency because of the extensive dissection and frequent inflammation in the pelvis, the older average age of the patients and because of the duration of bed rest necessary Frequent turning of the patients deep breathing and exercise of the extremities are the most important prophylaxis against these complications We routinely have these patients move the feet through flexion and extension hundreds of times each day and at night when awake If there is a slight rise in temperature, pain in the calf when exercising, or chest pain, an immediate search should be instituted for thrombophlebitis or possible pulmonary infarct from a phlebothrombosis Tenderness to deep pressure in the calf, a positive Homan's sign, tenderness to pressure at the femoro iliac junction, and swelling of the leg by actual measurement should call for prompt therapy In thrombophlebitis, lumbar paravertebral blocks with procaine should be done daily for at least three days Heparin and dicoumarol anticoagulant therapy should be started at the same time If the chest roentgenogram shows an infarct and the patient is over 50 years of age bilateral femoral vein ligation should be done at once Decision as to ligation or the use of anticoagulants only after a warning infarct in younger patients is decided on the basis of the findings in the chest and the general condition of the patient

The cause of *fever* after abdominoperineal resection is usually easily found The wound should be inspected carefully for abscess or infection around the colostomy The urine should be examined microscopically since urinary tract infections are common after prolonged catheter drainage If the cause is not found, the posterior space should be explored with the sterile glove, using the index finger to reach high into the sacral hollow Loculations of pus may be encountered and drainage is easily accomplished by breaking into them As stated before, thrombophlebitis must be suspected, and a search must be made for pulmonary infections particularly occult pulmonary infarct If prolonged use of sulfonamides has been necessary, drug fever must be considered

SUMMARY

Successful management of carcinoma of the rectum is dependent on careful preoperative preparation, a sufficiently radical operation and careful follow up not only throughout the postoperative period but for life. The preoperative preparation of the patient must be directed toward improvement of the general condition and proper preparation and evacuation of the bowel itself.

Few patients will require preliminary drainage by procedures such as cecostomy. Postoperative complications are infrequent but wound infection, thrombophlebitis and pulmonary and urinary tract infection and obstruction must be watched for and relieved. Proper management of the colostomy is of great importance for the patient's comfort and economic rehabilitation. A regimen is presented which has proved successful in a large series of cases in which abdominoperineal resection was required.

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excoriations around the anus which indicate pruritus fissures condylomas fistulas and pigmentation should be carefully noted Anal spasm and anal pain may signify a fissure or may be only the result of prolonged laxative abuse A rectal mass can be palpated in many instances if present although a mass high in the rectum may easily be missed unless a very careful examination is made

An anoscopic and proctoscopic examination is a necessary and important part of the procedure It should never be omitted in any case of rectal bleeding On anoscopic examination it may be possible to visualize a fissure which is usually nonpalpable Internal hemorrhoids are almost never palpable unless they are thrombosed, but can readily be seen through the anoscope Proctoscopic and sigmoidoscopic examinations will show the rectal mucosa and the lower sigmoid Most polyps are within reach of a 10 inch sigmoidoscope Many of these are entirely symptomless except for bleeding and in fact many polyps do not bleed except on rare occasions Rectal malignancy can be seen better than it can be palpated in every instance and certainly a differential diagnosis can be made visually with exactness when the examining finger may leave considerable doubt It is possible in most instances to pass the sigmoidoscope through the rectosigmoid and into the lower sigmoid so that lesions in this area can be visualized but gentleness and care in the use of the instrument must be scrupulously observed

Radiographic examination should be done in all doubtful cases but at the outset it should be realized that no roentgenologic procedure adequately demonstrates a lesion in the rectum itself unless it is a very large infiltrating lesion Barium given by mouth may show a cause for intestinal bleeding high in the gastrointestinal tract The blood in such cases will be black and tarry unless there is a very violent gross hemorrhage when the blood will be dark and clotted With lesions in the small intestine there will usually be dark blood but occasionally there will be bright blood if associated large bowel irritability is present Lesions in the right colon or in the transverse colon produce rectal bleeding which is usually darker and tends to be more clotted than with lesions in the left colon or rectum Blood from a cecal lesion may be unnoticed by the patient

A barium enema is the best means of showing an obstructing or infiltrating lesion in the sigmoid descending or transverse colon or the ascending colon Inflammatory lesions such as diverticulitis and occasionally tuberculosis will also be visualized by barium enemas Shortening and rigidity of the colon characteristic of ulcerative colitis are best visualized with a barium enema It is well to remember in this connection that the lesion of ulcerative colitis may be segmental may not involve the rectum or sigmoid and may be confined to a small area not more than 2 or 3 inches long in any part of the colon

A contrast enema, given after the barium enema has been evacuated, injecting air so that the colon is completely distended, is the best means of outlining colon polyps. This will also show an infiltrating lesion of the colon if it is only partly obstructing the lumen. It should be emphasized again that none of these methods may be relied upon to demonstrate a rectal lesion, and an adequate digital and proctoscopic examination cannot be replaced by any radiographic procedure.

Laboratory procedures, particularly a blood count, may reveal an anemia, which in turn may suggest a hitherto unsuspected lesion in the digestive tract. The presence of blood and pus in a smear taken from the rectum or mixed in with the stool indicates an organic lesion. Pus is never found in a normal stool, and blood only rarely when the passage of inspissated material has torn the mucosa.

DIFFERENTIAL DIAGNOSIS

The complaint by a patient of rectal bleeding does not always imply a long and tedious series of investigations. The history, digital examination and proctoscopic or anoscopic picture may suffice to give an adequate diagnosis. If more study is needed, the obvious things should be done first, such as a blood count, a barium enema, a contrast enema and a roentgenologic series of the upper gastrointestinal tract, in that order.

If none of these examinations show a definite cause for bleeding and if the bleeding persists, hospitalization is in order. It may be necessary to repeat one or more of the procedures several times in order to localize an obscure lesion. If the bleeding is slight and serious organic disease seems quite unlikely, it is entirely permissible to treat the patient for a short time with a bland, low residue diet and antispasmodics and to repeat any part of the examination and study after an interval of perhaps two weeks to a month's time.

If the bleeding is massive and there is no obvious cause which can be found, the most probable source is a benign polyp in the upper left colon. Exploratory laparotomy may be necessary to disclose the source of the bleeding and even this procedure may be disappointing. It is necessary and important to stress the need for a complete and careful emptying of the colon, not only of all barium, but of all fecal material before any laparotomy is attempted for this particular purpose.

The cause of rectal bleeding is usually obvious, but it may be so obscure that it presents a serious diagnostic challenge. As a rule, the cause of the bleeding is insignificant, but again it may indicate serious organic disease. In no case is it justifiable to dismiss the bleeding lightly. The burden of proof is squarely on the shoulders of the physician and it should not be shifted to the radiology department or the laboratory. The cause of bleeding should not be left unexplained. If

an adequate cause cannot be found, if the bleeding continues despite a careful dietary program, and if a repetition of the studies does not disclose a cause, exploratory laparotomy is not only justifiable, but mandatory. The cost to the patient in time lost and in hospital expense is considerable, but the cost of delay until the diagnosis becomes more obvious may mean that the patient has paid too high a price.

THE CLINICAL SIGNIFICANCE OF DIARRHEA

EVERETT D KIEFER

THE term diarrhea is applicable only to a symptom but the diarrheal diseases often present clinical problems in both diagnosis and treatment. For purposes of practical consideration the diarrheas may be classified as acute, functional and chronic organic diseases.

ACUTE DIARRHEA

The acute diarrheas are infectious or toxic in origin and include the endemic and epidemic diarrheas which are known as acute enterocolitis, intestinal flu, "summer diarrhea" and food poisoning.

The causative agent in this group is extremely variable. In cases of primary infection of the intestinal tract some member of the *Salmonella* group of organisms is often found. Hardy and Watt have emphasized the importance of the *Shigella* paratyphosa bacilli as a cause of epidemic acute diarrheas. Apparently these organisms produce severe bacillary dysentery in tropical countries but in temperate zones they may cause acute, comparatively mild disorders which are clinically indistinguishable from the diarrheas caused by the *Salmonella* infections. For some time it has been suspected that there is an airborne enterotropic filtrable virus which causes acute diarrhea, and recently Reimann, Hodges and Price have reported success in transmitting an acute diarrhea to volunteers by means of the inhalation of a fine mist made from filtered nasopharyngeal washings or from stools of patients. Parenteral infections, particularly of the ear, nose and throat, by staphylococci, streptococci or pneumococci may give rise to toxic diarrhea. Staphylococci and other organisms are involved in cases of acute food poisoning, while the products of bacterial decomposition are thought to be responsible for the violent and acute diarrheas known as "sewage poisoning."

The acute diarrheas may be identified clinically by their sudden onset with accompanying signs of acute gastrointestinal irritation such as vomiting and abdominal cramps. Fever, general malaise and prostration are prominent features. Mild upper respiratory symptoms may be present. The epidemicity as manifested by the occurrence of other cases in the patient's family or throughout the community is a diagnostic point. The duration of the acute diarrheas is characteristically short, approximately from two to seven days, and usually the patient has fully recovered by the end of the second week from the time of onset. Stool cultures may be helpful in the diagnosis in a limited

proportion of cases. Actually however they are of little value in the sporadic case. If the stool can be cultured within forty eight hours of the onset of symptoms a fair proportion of positive results may be expected but as a rule by the time the patient seeks medical aid the stool culture is negative. On the other hand in the control of wide spread or explosive outbreaks of diarrheal disease the identification of the offending organism by stool culture is of definite value.

Treatment other than symptomatic therapy is usually unnecessary for the acute diarrheas since the disease is of short duration self limited and rarely serious in adults. Food except for hot water and hot tea may be completely eliminated for from twenty four to forty eight hours or the diet may be restricted to boiled rice farina plain soda crackers and boiled milk. Deodorized tincture of opium in dosages of 10 minims every four hours tends to keep the patient more comfortable. After the first acute stage bismuth or kaolin may help to bring about formation of the stools. The sulfonamide drugs are rarely indicated but there seems to be no harm in giving the poorly soluble succinylsulfathiazole although the benefit derived from this form of therapy is questionable. If fever is persistent or if stool cultures are positive for one of the Flexner strains of *S. paratyphenteria* sulfadiazine or sulfathiazole may be used. This medication should be accompanied by measures which insure an adequate output of alkaline urine otherwise the diarrhea causes concentration of the urine and crystalluria.

FUNCTIONAL DIARRHEA

Diarrheal disorders designated as functional include those caused by irritating food or drink food idiosyncrasies laxative drugs nervous factors achlorhydria and irritable colon.

Dietary Causes—Certain individuals apparently have hypersensitive gastrointestinal tracts and suffer from diarrhea as a result of the ingestion of foods which are mechanically and chemically irritating to the intestine. These patients are frequently food faddists and indulge in liberal quantities of so called "health foods" which are prepared with special emphasis on their high residue and active laxative properties. Highly seasoned foods as well as excessive quantities of raw fruits and raw vegetables are common causes of intestinal hypermotility.

Alcoholic beverages can cause loose stools in some individuals and diarrhea may be one of the chief complaints of the chronic alcoholic.

Gastrointestinal allergy occasionally causes diarrhea and may be suspected if the patient gives a history of diarrhea which always occurs shortly after eating a particular food. Such a history does not always indicate an allergic disturbance however. For example it is not uncommon for a patient to report diarrhea after drinking milk. On questioning however it usually develops that the diarrhea has followed

the drinking of large quantities of ice cold milk but that warm milk in reasonable quantities is well tolerated. If the intestinal disturbance is accompanied by urticaria, particularly around the lips, the allergic nature of the disorder is probable. The diagnosis is best made by trial elimination of the suspected food. Skin tests for gastrointestinal atopy have proved unsatisfactory and often misleading.

A habit of drinking excessive quantities of fluids is sometimes a cause of chronic diarrhea which may be overlooked. Ice cold drinks in particular are active stimulants of intestinal motility.

A probable diagnosis of functional diarrhea from dietary causes may be made by inquiry into the patient's eating and drinking habits.

Drugs—Some patients have diarrhea from the habitual use of laxatives which they take for real or fancied bowel disorders or because of painful anorectal conditions. Other medicines taken for other conditions may stimulate intestinal motility. An inquiry into the medications frequently used by the patient may explain the bowel symptoms.

Achlorhydria has been blamed for the so-called gastrogenous diarrhea, but it is doubtful if achlorhydria *per se* causes diarrhea. Rapid emptying of the stomach may be a factor and patients with achlorhydria are apparently more susceptible to mild food infections probably due to the absence of the sterilizing effect exhibited by normal gastric juice. Treatment of this condition by replacement therapy is entirely inadequate in the dosages of hydrochloric acid which can be given. A bland diet usually suffices to keep the condition under control.

Nervous Factors—Diarrhea of nervous origin is well recognized and is often characterized by an immediate urge to go to stool coincident with emotional excitement. Chronic diarrhea is often aggravated by nervous upsets and according to the newer concepts of psychosomatic disease it is possible that prolonged and intense psychic stimuli may even lead to structural changes in the bowel wall.

The diarrhea which frequently is associated with severe thyrotoxicosis is an example of disturbed intestinal motility motivated by autonomic nervous influences.

CHRONIC ORGANIC DIARRHEA

A third variety of diarrheal disorders may be called the chronic, organic group since the diarrhea is usually chronic or at least persistent and is always caused by organic disease such as cancer, benign tumors, polyposis, diverticulitis, tuberculosis, ulcerative colitis, bacillary dysentery, amebiasis, ileitis, sprue and other diseases of the small and large intestine.

Although the acute and functional types of diarrheal diseases are usually mild, benign disorders requiring no more than symptomatic expectant treatment and correction of living habits, this third group is

made up of serious conditions and any delay in diagnosis, or time spent on expectant therapy, may constitute a serious error in management. A case of diarrhea from organic disease usually presents one or more clinical features which should arouse suspicion that it falls within the more serious group. These may be listed as (a) a duration of diarrhea for more than three weeks, (b) the diarrhea represents a distinct change from the previous bowel habits, (c) the patient's age is over forty, (d) blood or pus in the stool, (e) persistent fever (more than a week), (f) signs of partial or intermittent intestinal obstruction, (g) malnutrition, and (h) anemia.

DIAGNOSIS

Any case of diarrhea presenting one or more of the above clinical features is deserving of diagnostic study until an adequate explanation of the symptom has been established. The study cannot be considered to be complete unless it includes the general physical examination, the digital examination of the rectum, proctoscopy, roentgenologic studies of the gastrointestinal tract, microscopic examination and culture of the stool, tests for free hydrochloric acid in the gastric juice, and routine blood counts and hemoglobin determination.

Rectal Examination—The digital examination of the rectum may explain a diarrhea by disclosing a new growth or a stricture within reach of the examining finger. It is also possible to palpate a mass involving the sigmoid when it is low lying in the pelvis and can be felt through the rectal wall.

Proctoscopy—The proctoscopic examination is a most satisfactory procedure because by direct inspection of the mucosa, the slightest abnormality is easily detected. Unfortunately the scope of this examination is limited to the rectum and lower sigmoid. This procedure is of additional value in that it facilitates the collection of a stool specimen for immediate microscopic examination.

Roentgenologic Examination—The barium enema is the most useful roentgenographic procedure in the study of diarrheal disorders. Adequate preparation with castor oil may be required but in cases of active severe diarrhea preparatory cathartics and enemas are not usually necessary.

Obstructive lesions of the colon and gross changes in the bowel wall are easily detected by the barium enema. On the other hand, small nonobstructive lesions may require repeated barium enemas as well as the double contrast air enema for their demonstration. Nonobstructing lesions at the rectosigmoid junction are easily missed by the barium enema. This is one of the most important reasons why x rays and the proctoscope should supplement each other in the study of every case of diarrhea.

Since some diarrheas originate in the small intestine, it is often

desirable to study this part of the intestinal tract with serial films after a barium meal

Stool Examination—The gross inspection of the stool may reveal considerable information. A bulky, foamy, foul, rancid stool is indicative of sprue or a related condition. A watery foamy stool is suggestive of a small intestinal disorder. The presence of pus and blood is indicative of an exudative or ulcerative condition in the colon or rectum.



Fig 256—*Carcinoma of proximal transverse colon*. Patient's chief complaint was diarrhea. Barium enema demonstrated typical annular filling defect with rigid channel and characteristic overhanging or "hooking" of the barium column around the tumors.

The immediate microscopic examination of a drop of stool or exudate obtained through the proctoscope and diluted with normal saline solution is a practical method for searching for the motile forms of amebae. The presence of blood cells, pus cells and parasitic ova may be established by this simple test.

As a rule, it is advisable to send a stool specimen to a laboratory for culture and for concentration procedures which increase the probability of finding amebic cysts and parasitic ova.

The diagnosis of intestinal disease depends therefore upon the clinical picture developed from several diagnostic procedures which should be correlated by a clinician who is familiar with the shortcomings as well as the significance of each test

TUMORS

Diarrhea is not an uncommon symptom of new growths of the colon and rectum. The bowel dysfunction tends to be progressive in severity and the diarrhea tends to be intermittent and usually associated with signs of incomplete obstruction such as severe cramps, loud borborygmi, visible peristalsis, tenesmus and periods of obstipation. The frequency of gross blood in the stools depends upon the location of the malignant lesion. If the growth is in the right colon, blood is rarely seen, but it is present in about one fourth of the cases involving the left colon and nearly all of the rectal tumors produce gross bleeding. The diagnosis is made either by visualizing the tumor through the proctoscope or by demonstrating the characteristic obstruction or defect by roentgenogram (Fig. 256).

The treatment of all new growths of the large bowel is surgical.

DIVERTICULITIS

Acute diverticulitis is a comparatively rare complication of diverticulosis of the colon which is a very common condition. Diarrhea is often a symptom of the recurrent attacks of diverticulitis to which certain individuals with diverticulosis seem to be particularly susceptible. Frequent small watery stools associated with lower abdominal pain, tenderness, fever and leukocytosis constitute the general clinical aspects of this disease. Although the stools may be free of abnormal constituents, microscopic examination often does show pus cells and red blood cells. It has been reported that in up to 22 per cent of the cases of diverticulitis, visible blood may be present in the stools. Massive hemorrhages have occurred in acute diverticulitis. Symptoms of partial obstruction and the presence of a palpable mass also increase the difficulty in the differential diagnosis of diverticulitis and carcinoma.

Fever, tenderness and leukocytosis are signs favoring an inflammatory process rather than new growth. The proctoscopic findings in diverticulitis are a normal mucosa, occasionally some fixation of the sigmoid and usually marked pain associated with any attempt to introduce the scope into the sigmoid. Certain roentgen characteristics have diagnostic value. Marked spasm and tenderness of the sigmoid in the presence of demonstrated diverticula are presumptive evidence of diverticulitis. When a partially obstructing inflammatory mass is demonstrated by roentgenograms, the filling defect is characteristically

longer than that of an annular new growth and the ends are pointed or fusiform (Fig 257).

The treatment of acute diverticulitis consists of complete bed rest, a bland, low residue diet, and administration of antispasmodics and sulfonamides.



Fig 257 - In a case of sigmoid diverticulitis the complaint was diarrhea. Barium enema showed a large filling defect in sigmoid and diverticulosis. The character of the defect was (1) the unusual length of the defect, (2) the absence of "hooking" and (3) tenderness and fixation on palpation.

In cases of perforation and persistent obstruction, temporary colostomy may be necessary to permit resolution of the inflammatory mass or later surgical resection.

The final differentiation from malignant disease may rest upon the improvement under treatment as demonstrated by repeated roentgenologic studies.

INTESTINAL TUBERCULOSIS

Involvement of the gastrointestinal tract in cases of tuberculosis is often heralded by diarrhea. Since the ileocecal region is the common site of tuberculous ulcerations, diarrhea from intestinal hypermotility

is the result. The ultimate fibrosis, thickening and granuloma formation may also give rise to chronic diarrhea which may be severe and debilitating. Crampy, colicky abdominal pain is characteristic and often a prominent symptom.

The diagnosis is made by demonstrating by roentgenograms increased irritability of the ileum and right colon with changes in the mucosal pattern and in the outline of the lumen (Fig. 258). When



Fig 258—Ileocecal tuberculosis. Pain and diarrhea were the chief complaints. Pulmonary tuberculosis was present. The characteristic hyperirritability of the cecum, the obliteration of the normal mucosal pattern, the contraction of the lumen and fistula (arrow) formation are shown.

these findings are present in connection with active pulmonary tuberculosis with positive sputum, they are strong presumptive evidence of ileocecal tuberculosis.

The finding of tubercle bacilli in the stools is not diagnostic of gastrointestinal tuberculosis unless it can be proved that the sputum is negative.

The chronic tuberculous anorectal lesions and perineal fistulas are generally accepted as secondarily infected, previously existing lesions

of this region by the B tuberculosis present in the feces as a result of swallowed sputum or a tuberculous lesion in the intestinal tract (Kantor)

The chronic hypertrophic form of intestinal tuberculosis produces fairly well localized granulomatous tumors, usually of the ileocecal region. The symptoms are chronic or intermittent diarrhea, pain and other signs of partial obstruction associated with a palpable mass. The history is usually longer and the systemic effects, particularly the anemia, are much more pronounced in cases of new growths of the cecum of corresponding size.

The roentgenologic differentiation from carcinoma of the cecum is not always possible, but in general the tuberculoma produces a smaller filling defect in the lumen and a much more extensive thickening of the wall of the cecum. Furthermore, the tuberculous lesion usually includes the terminal ileum which is an important differential point.

The treatment of intestinal tuberculosis should be conservative. In more recent years, surgical resection has been limited to cases with obstruction or other complication. A bland, high caloric, high vitamin diet, artificial beliotherapy, along with the measures usually indicated in the treatment of the pulmonary phase of the disease, have greatly improved the prognosis in this disease.

CHRONIC ULCERATIVE COLITIS

Chronic ulcerative colitis is discussed elsewhere in this volume. Chronic severe diarrhea is the most outstanding symptom of this disease.

BACILLARY DYSENTERY

Dysenteric infections due to *Shigella dysenteriae* are a common cause of acute and chronic diarrheal disease in the tropics and subtropics and are not infrequently met with in temperate zones. Although the disease is characteristically an acute colitis, chronic persistent diarrheas sometimes result. It has been thought that a bacillary dysenteric infection may lead to a chronic colitis indistinguishable from idiopathic ulcerative colitis.

Clinically, the disease is characterized by an acute onset of fever, abdominal pain, vomiting and diarrhea. The associated toxemia and prostration are extremely marked. The clinical severity may vary within wide limits. The usual duration is from five to fourteen days but more chronic forms of the disease occasionally follow the acute stage.

The diagnosis is usually made clinically and confirmed by culture of the stool. In the less severe cases the stools may be negative after the third day of the disease. The serum agglutination tests are of little

value in clinical diagnosis since they do not become positive until the third week after the onset.

The proctoscopic examination in the acute phase shows a diffusely inflamed mucosa, with edema, exudation and some shallow ulcerations. Roentgen studies are not usually possible in the acute stage but when done show evidence of marked spasm and irritability of the bowel and edema of the wall of the intestine.

Treatment is largely supportive and symptomatic. Bed rest, a light, bland, low residue diet, warm fluids, and opium constitute the basis of therapy. Parenteral administration of glucose and saline solutions may be necessary in some cases.

Sulfonamides—Although the most dramatic action of these new drugs has been against the coccal forms of microorganisms, experiments have shown that they are also bactericidal, *in vitro* at least, for several members of both the *Shigella* paradyseutery and the *Salmonella* groups of pathogenic bacilli and are bacteriostatic for several others (Stearns and Finland, Neter).

The degree of activity against the intestinal coliform flora as exhibited by the various sulfonamides diminishes in the following order: sulfapyridine, sulfadiazine, sulfathiazole, sulfaguanidine, succinylsulfathiazole and sulfanilamide (White).

The reports in the literature upon the clinical effectiveness of the sulfonamides in the treatment of colon infections have been somewhat conflicting. Many of the favorable reports have been based upon clinical impressions of the results obtained in uncontrolled series. In studies in which a control group of untreated cases was compared with those receiving the drug there was much less enthusiasm over the effectiveness of chemotherapy, although in some reports there was fairly convincing evidence of benefit from the drug (Baker, Swyer and Yong, Hardy and Watt, Adams and Atwood, Sandweiss, Smith).

The clinical experiences recorded in the literature indicate that the Flexner varieties of *Shigella* paradyseuterieae respond most favorably to sulfonamide therapy, while Sonne dysentery and *Salmonella* infections are the least favorably affected.

Most observers agree that the clinical effectiveness is in direct proportion to the absorbability of the drug used. In the active acute stage of bacillary dysentery, the earlier and more dramatic effects shown by the highly absorbable sulfadiazine and sulfathiazole as compared to the later and less obvious effectiveness of sulfaguanidine are probably due to the presence of the *Shigella* organism in the bowel wall rather than in the bowel content. The offending organism is reached more directly through the blood stream and a high blood level is desirable. Therefore, in the treatment of bacillary dysentery in the acute stage with fever and other systemic symptoms, either sulfadiazine or sulfathiazole is indicated.

The use of the moderately soluble sulfaguanidine and the poorly soluble succinylsulfathiazole has been most favorable in the treatment of the carrier state after clinical recovery. It has been reported that the stool cultures become negative several days sooner under the influence of medication with these drugs (Ferriman and MacKenzie).

The chief usefulness of succinylsulfathiazole is apparently its prophylactic effect. It has been shown that in the dosage recommended the concentration in the feces is well above the concentration necessary for bacteriostasis (Brewer).

AMEBIC DYSENTERY

In a relatively small percentage of cases amebic dysentery may occur as an acute fulminating diarrheal disease with signs and symptoms of an "acute abdomen," often leading to laparotomy for suspected appendicitis or other acute inflammatory condition. In the usual acute case the abdominal pain, fever, leukocytosis, prostration, tenesmus and bloody diarrhea constitute a clinical picture indistinguishable from severe bacillary dysentery.

The most common form of intestinal amebiasis is a chronic carrier state with intermittent bouts of diarrhea and abdominal symptoms and chronic ill health.

The diagnosis of amebic dysentery depends upon the demonstration of *Endamoeba histolytica* in the stool or exudate from the bowel. The finding of the motile trophozoites constitutes the most convincing proof. They are most abundant in diarrheal stools or in the watery movements following catharsis. When the stools are solid, the amebae have largely become encysted. The cysts are somewhat more difficult to discover and identify, but flotation concentration methods of preparing the stool increase the chances of finding them.

The proctoscopic examination is of considerable value in diagnosis since in many cases the characteristic localized ulcerations are present. However a negative proctoscopy does not rule out intestinal amebiasis. A specimen of mucus or exudate should be removed from the rectum at the time of proctoscopy and examined immediately under the microscope. The motile amebae, when present, are particularly active and easily identified in this way.

The roentgenogram is of little value in diagnosis. It usually demonstrates an irritable, spastic bowel without definite evidence of organic disease.

The treatment of amebic dysentery consists of the routine measures for diarrhea plus specific chemotherapy. Emetine is the drug of choice for the acute case since it gives the quickest relief of symptoms. Because it is a neuromuscular toxin and is cumulative in its effect, emetine is a dangerous drug. Its use should be limited to a single

course of intramuscular injections of 1 grain daily for from six to ten days

Chiniofon (yatren iodoxyquinoline sulfonate) a compound containing approximately 26 per cent iodine, is probably the safest and most effective amebicide. It should be given following the course of emetine in active amebic dysentery and should be used without emetine in carriers. The dosage is from 0.5 to 1.0 gm. by mouth three times daily for from eight to ten days.



Fig. 259—*Regional ileitis*. Diarrhea was a prominent symptom. This film taken two hours after a barium meal shows separation of the small intestinal loops, contraction, rigidity and obliteration of the normal mucosal markings involving several loops of ileum.

No amebicide is successful in eradicating the disease in 100 per cent of cases. Protracted crises are usually given additional courses of other iodine drugs such as vioform or diodoquin or an arsenical such as carbarsone.

REGIONAL ILEITIS

Chronic inflammatory disease of the small intestine may be the cause of diarrhea. Acute regional ileitis may present a clinical picture

indistinguishable from acute appendicitis although diarrhea is more common in acute ileitis. The more chronic forms of this disease often give rise to chronic diarrhea, intermittent abdominal pain, particularly following meals, mild fever, leukocytosis and anemia. In severe cases malnutrition, hypoproteinemia and avitaminosis may result from the interference in intestinal absorption. In some cases an elongated, ropy, firm abdominal mass can be felt, usually in the right lower quadrant.



Fig 260—*Deficiency disease* Diarrhea was a prominent symptom. This film, taken one hour after a barium meal, shows changes involving the entire small intestine. Edema of the wall and mucosa and impairment of the neuromuscular mechanism have caused irregular dilatations, with "puddling" as well as coarsening and obliteration of the normal mucosal markings.

The diagnosis is made by roentgenologic study of the small intestine with serial films following a barium meal (Fig. 259).

The proctoscopic examination and the barium enema are of value only in ruling out disease of the colon.

The stools in ileitis are characteristically foamy and rancid. The microscopic examination reveals no abnormal cells, but the occult blood tests are usually strongly positive.

The treatment of regional ileitis is essentially surgical particularly if the disease is well localized or is complicated by obstruction or perforation of the intestine (Kiefer and Ross)

The medical management is similar to that used in the treatment of ulcerative colitis

SPRUE

Diarrhea may be an outstanding symptom in conditions characterized by impaired absorption in the small intestine. In this group of disorders are non tropical sprue, steatorrhea, celiac disease and pancreatic fibrosis.

The diagnosis of this type of disorder is made from the study of the stools, the blood and routine studies of the gastrointestinal tract. Edema of the small intestinal mucosa gives rise to the characteristic deficiency pattern (Fig 260).

Treatment consists of a high protein, low residue diet with high vitamin administration both by mouth and parenterally, liver extract intramuscularly and prepared stomach by mouth. The starch in the diet is supplied largely by bananas prepared in various ways or raw.

Transfusions of blood or plasma are often used to overcome the hypoproteinemia and the anemia.

SUMMARY

Diarrhea as a symptom has been reviewed in the light of its clinical significance.

The clinical features which aid in distinguishing between unimportant and serious diarrheal conditions have been discussed.

The diagnostic methods which should be employed in the study of patients with diarrhea have been outlined.

Descriptions of some of the important diseases which cause diarrhea have been included along with brief outlines of the diagnosis and treatment.

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THE USE OF DOUBLE CONTRAST ENEMAS IN LESIONS OF THE COLON

MAGNUS I SMEDAL

THE use of air in the colon as a contrast medium in conjunction with barium to produce a double contrast enema is a very valuable procedure and should be employed more often. This procedure is used in this Clinic in all cases of suspected polyps, and also in all cases in which polyps are demonstrated by proctoscopy and sigmoidoscopy in order to determine the presence of additional polyps. We are rarely satisfied with a single examination. If what is believed to be a polyp is demonstrated or if in a case of unexplained hemorrhage the double contrast enema is negative, a second examination is always done in order to confirm the presence or absence of a lesion. By repeating the examination in cases in which the findings are positive, we are less likely to call a fecal bolus a polyp. In the negative cases it is assumed that a polyp was not found on one examination.

In a previous report,¹ the fact was stressed that in a series of 827 cases of cancer of the colon and rectum, in 14 per cent the carcinomas were found to have arisen on the basis of a preexisting polyp and were true malignant adenomas. It is a regrettable fact that a double contrast enema is not a simple procedure, the interpretation of the films is not easy and its use in the usual case is practically limited to the left colon. Occasionally, the right colon can be visualized, but in most cases we find that in order to get a small amount of barium into the right colon the left side is overfilled and the resulting air contrast roentgenogram is of no value.

Double contrast enemas have proved to be of value in a few cases in which a differential diagnosis is needed between diverticulitis and malignancy, especially when diverticulitis is known to exist. A good double contrast enema enables one to see the mucosal pattern and when viewed stereoscopically, the lumen and mucosal pattern of redundant and overlapping loops in the distal colon are seen to much better advantage than following the ordinary barium enema. The value of stereoscopic films cannot be overemphasized.

Method.—Preparation is all important and we still depend upon a castor oil purge of 1 to 2 ounces given the night before examination. Meals in the interval between the purge and examination should be light to reduce the bulk in the colon. Fluids should be limited for six hours before the contrast enema. If sigmoidoscopy precedes the contrast enema the surgeon usually orders a saline enema, given just before the sigmoidoscopy. An interval of two hours should then elapse before

DOUBLE CONTRAST ENEMAS IN LESIONS OF COLON



Fig 261.



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the contrast enema film is made in order to allow sufficient time for absorption of excess fluid in the colon

Since most of the contrast air enema films are made for the purpose of studying the left colon sufficient barium is given slowly to allow a small amount to enter the descending colon. Care must be taken to avoid distending the rectum because more barium will back into the descending portion than one wants

The patient is then allowed to expel as much barium as possible following which air is injected using an air pressure bulb attached to a rectal tube. Sufficient air is given to allow the cecum to distend slightly. We try to avoid getting air into the ileum since its presence there tends to obscure the sigmoid. The patient is then turned to the prone position and stereoscopic films are taken with Bucky apparatus. Both films are taken while the patient holds his breath in order to get proper stereoscopy. A second set of stereoscopic films is taken after as much of the air has been expelled as is possible. We find the empty air contrast films very valuable when looking for polyps as will be shown in the accompanying illustrations

Figure 261 is a *full* double contrast air enema film which shows a soft tissue mass roughly 1.5 cm in diameter lying within the lumen of the proximal sigmoid. There are irregular flecks of barium scattered over its surface. Figure 262 is an *empty* contrast air enema film taken after the air has been expelled and shows an area in the left lower quadrant with barium markings similar to that seen in the *full* film. The bowel has contracted so that the lumen is no longer visualized. At operation a polyp 1 cm in diameter and having a pedicle 5 cm long was removed from the sigmoid

Figure 263 is an *empty* double contrast film showing an apparent intraluminal shadow. Note however that there is a good mucosal pattern leading into the area. Figure 264 which is the *full* double contrast film shows no unusual shadow in this area. Stereoscopically the object in the *empty* film is seen to be a bend in the sigmoid viewed on end

Note the shadow in the proximal sigmoid on the *full* film with the obvious long stalk of a polyp. On the *empty* film the bowel is narrowed in the same place but the polyp has been covered over by barium and it has slid down the bowel

Diverticulosis—Figure 265 illustrates a case of diverticulosis. This is not intended to infer that we use double contrast enemas to make that diagnosis but is included to show how well the lesion is visualized. Viewed stereoscopically the intact lumen and mucosa are seen throughout the rectosigmoid and sigmoidal areas. The redundancy and overlapping of loops do not obscure any portion. Note the mucosa in the area of spasm. The barium enema film in this instance of course is characteristic of diverticulosis (see Figs 266 and 267)



Fig 263



Fig 264



Fig 265



Fig 266



Fig 267.



Fig 268



Fig 269



Fig 270



Fig 2 1



Fig 272

Diverticulitis—The regular barium enema is characteristic of diverticulitis without gross inflammatory mass. A spot film of the area is shown in Figure 268. The double contrast enema is shown in Figure 269. Its advantage is that, viewed stereoscopically, a much more detailed study can be made of the lumen of the bowel which is seen to be narrowed but intact, except for the diverticula. The lumina and mouths of the diverticula can be clearly seen.

Diverticulitis with Superimposed Carcinoma—This patient had had a known diverticulitis of the sigmoid for years, malignant disease had been suspected in March 1944. A spot film of a barium enema made at that time shows narrowing of the lumen of the sigmoid with some normal mucosal markings present. Numerous diverticula may also be seen up to the edge of the narrowed portion (Fig. 270).

In December 1945 a barium enema (Fig. 271) showed increased involvement of the sigmoid with gross distortion of the mucosal pattern. This should be sufficient for a diagnosis of carcinoma but we felt that a double contrast enema contributed considerably. Figure 272 is the double contrast enema film made on the same date. Viewed stereoscopically it is superior to the ordinary barium enema in showing the detail of the mucosal distortion, the amount of actual narrowing of the lumen and the definitely irregular shelving margins characteristic of carcinoma. Both carcinoma and diverticulitis were present in the specimen resected.

SUMMARY

1 Double contrast air enemas are invaluable in searching for polyps in the distal colon.

2 The double contrast enema should be used more frequently in cases of diverticulitis when a differential diagnosis from carcinoma is wanted.

3 It should be remembered that the regular barium enema must precede the double contrast enema in all cases of suspected disease of the colon.

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ROENTGEN DIAGNOSTIC METHODS FOR DETECTION OF COLONIC LESIONS

MARTIN L. TRACEY

For lesions above the rectum and sigmoid the method of choice for determining location and extent of colonic lesions is roentgenography following the barium enema. The rectum and rectosigmoid seldom present positive findings except in large, far advanced lesions. Therefore, with (1) any change in bowel habit (2) any unexplained rectal bleeding and (3) anemia without visible bleeding, a digital and proctosigmoidoscopic examination should precede the barium enema. It is wise even with visible anal lesions to rule out ulcerative, inflammatory and neoplastic lesions of the upper colon with these procedures.

Preparation is not used. It is believed unnecessary because it will mask functional disturbances by promoting spasm and irritability, and because we feel that no greater numbers of lesions are overlooked by doing the barium enema without preparation than with preparation. The experienced roentgenologist who visualizes a suspicious area may wish to recheck it with preparation and an air contrast film. A suspicious area both with and without preparation in the same location is excellent positive evidence. One may often suspect a defect in an undisturbed (unprepared) colon because of noting a dilated feces-filled colon behind an area of apparently normal caliber; this area can then be carefully rechecked following preparation. We feel that polyps and small lesions will need preparation and air contrast studies when suspected and undetected in the unprepared colon.

The technic of the barium enema should in general follow a plan. *To judge functional disturbances—by rate of flow (average two to four minutes) and without interruption, and the presence of more than average, or absence of, distress and tenderness—one should have the can containing the barium at a standard fixed height above the floor and table.* A small amount is run in with the patient supine so as to fill the rectum and then the patient is usually rotated far enough to the left to displace the sigmoid from the rectum (separate loops are palpated and fixation and filling defects determined with the patient so rotated). Excellent visualization is usually obtained and films are taken if there are positive findings. Infrequently, the sigmoid loop will be right-sided and rotation toward the right hip will be necessary. Finally, should the sigmoid remain in the pelvis, turning the patient into the prone position will throw the sigmoid up into the abdomen for better visualization but will preclude palpation.

As the enema is continued through the descending colon palpation should be done to observe flexibility and intraluminal fixed defects.

The flexures are equally important and rotation to separate the ascending and descending limbs of the flexures for perfect visualization is usually necessary. As a rule the distal transverse colon may be thrown off the splenic flexure by turning the patient toward the right hip and conversely the proximal transverse colon is separated from the hepatic flexure by turning the patient toward the left hip. One further maneuver is necessary to visualize the cecum and terminal ileum and that is rotation back toward the right hip. At times experience dictates different maneuvers aided by manual separation of loops particularly to visualize a low cecum obscured by a large rectum or right sided sigmoid loop.

Spot films with cone pressure are quite valuable to bring out detail and record small intracolonic lesions on the film.

To be noted in diagnosis of irritable colon are rate of flow, hesitation and spasm, dilatation, extreme distress, absence of sensation of filling, tenderness confined to colon, miss peristalsis and amount of barium used (normal 1000 to 1500 cc.).

With severe distress and spasm at the outset the patient should expel the barium instilled and return immediately for another barium enema. Because of the antispasmodic effect of the initial barium a second attempt will usually be successful with much less distress to the patient.

A double contrast air enema is useful to demonstrate polyps. Other intraluminal filling defects, estimation of the size of the lesion and tuberculosis of the cecum and ascending colon may also be demonstrated by contrast air enemas. It should be ordered when negative digital sigmoidoscopic and barium studies have failed to explain rectal bleeding, change in bowel habit or anemia thought to be gastrointestinal in origin. Preparation is a *sine qua non*; it should be done even with diarrhea except in acute inflammatory lesions or debilitated patients. Castor oil 1 to 1½ ounces or citrate of magnesia 6 to 12 ounces should be given the night before. If ineffective a cleansing enema (3 pints of soap suds or saline) is given the next morning. Then a small amount of barium is introduced to fill as far as the lower descending colon if atonic and into the upper descending colon if spastic. The patient is urged to expel as much as possible when he is sent to the toilet. Then air is introduced and followed over to the cecum. Rarely will small lesions be visualized fluoroscopically unless the site is previously suspected. Stereoscopic films or at least a film while the colon is full of air and a recheck film after expulsion of air should be ordered.

In patients who find it impossible to retain the enema, some information regarding the colon may be obtained by three six and

twenty four hour films after a barium enema or by a barium meal followed by a saline cathartic and a film after catharsis to outline the mucosa

The cecum and ascending colon may be very deceptive. If information regarding these areas is not adequate from these procedures, a Miller-Abbott tube may be passed into the lower ileum and a small amount of dilute barium introduced to outline the area, or a Rehfuess tube passed into the duodenum and a small intestinal barium enema given—after which the barium should be at the cecum in fifteen minutes and the area studied from there on.

Every physician attempting to manage gastrointestinal problems should be able to do his own digital and sigmoidoscopic examinations. The examinations, coupled with these methods of investigating the colon, will result in a very high percentage of accurate diagnoses.

PRIMARY RESECTION OF THE RIGHT COLON

RICHARD B. CATTELL AND BENTLEY P. COLCOCK

DURING recent years, there has been a wider utilization of the one stage resection for carcinoma of the colon as well as for benign and inflammatory lesions. Similarly, the one stage abdominoperineal resection for carcinoma of the rectum has largely replaced the various two stage procedures formerly employed. There are a number of reasons why the one stage resection is favored. Certainly, adequate removal of the growth with immediate establishment of continuity by aseptic or open anastomosis is the simplest technical procedure for the surgeon. The shorter period of hospitalization and the single operative procedure seem advantageous to the patient, both from the standpoint of comfort and economic reasons. It has long been demonstrated that the exteriorization principle in avoiding an intraperitoneal anastomosis has been a safe procedure and has given good results from the standpoint of mortality and five year survival figures. If there is to be general adoption of primary resection it must be demonstrated that it can be done with equal safety.

A number of aids have been developed in recent years to increase safety with primary resection. Without question a much better preoperative preparation is carried out in patients having carcinoma of the colon. The use of a diet high in protein, carbohydrate and vitamin content, the generous use of blood transfusions and better preparation of the intestine itself by saline purge and colonic irrigations have improved the condition of the bowel at the time of operation. The widespread administration of the sulfonamide drugs, particularly sulfaguanidine, succinylsulfathiazole and sulfathaladine have decreased the bacterial flora of the intestinal contents. Intubation of the small intestine preoperatively by the Miller Abbott tube in mildly obstructed cases and the use of this same method of decompression during the immediate postoperative period, have likewise improved the condition of the bowel and avoided undue intraluminal pressure following resection. Equally important, however, has been an increasing surgical experience with these cases and more satisfactory utilization of the long employed methods for removal of the lesion and anastomosis.

A review of the recent literature reveals a number of reports which demonstrate that primary resection has been adapted to a large number of patients with carcinoma of the colon with a high operability rate being maintained. Likewise, morbidity and mortality figures have been shown to be satisfactory. It is quite possible, however, in some

of the series reported that the modified Mikulicz procedure has been applied to less favorable cases, particularly those with moderate degrees of obstruction or perforation when it was felt that a primary resection was not advisable. Whipple reported 51 primary resections in 1943, with a mortality of 11.8 per cent. He utilized a Miller-Abbott tube as a means of decompression during the immediate postoperative period and feels that this is an important adjunct to primary resection. Jones reported 45 cases, with a 13 per cent mortality. Twenty-one cases were reviewed from Wangensteen's clinic with but 1 surgical fatality. In a more recent report of primary resection for carcinoma in different sites in the colon, Clute reported 8 resections of the right colon with 1 death.

For a number of years the procedure of choice at the Lahey Clinic has been a modified Mikulicz type of resection for all lesions of the colon. This operation has been proven in our hands to be adaptable to both favorable and unfavorable lesions, and has been employed in over 450 patients with a mortality of approximately 11 per cent. We are frequently asked whether we utilize a one stage primary resection for carcinoma of the colon. During 1945, 84 patients with cancer of the colon were operated upon and 77 resections of the colon were carried out. Sixty-two of these patients were operated upon by a two stage modified Mikulicz procedure. Two patients had an initial anastomosis for the relief of obstruction, followed by a second stage resection. Thirteen patients had primary resection of the right colon. These did not include a considerable number of patients with regional enteritis, all of whom had resection of the ileum and right colon by the modified Mikulicz plan. Of the 77 resections during 1945, 30 patients had the lesions in the cecum, ascending colon, hepatic flexure or right half of the transverse colon, so that 39 per cent of patients with lesions in this portion of the colon had primary resection.

These patients were all prepared in an identical manner. None of the sulfonamide drugs was utilized preoperatively and none of the patients with primary resections had parenteral or oral sulfonamides postoperatively. Intragastric continuous suction, as suggested by Singleton, and occasional postoperative intubation by means of the Miller-Abbott tube, as suggested by Whipple, were used in some cases. Primary resection was not done for perforated lesions or if obstruction was present. Each patient received a saline purge of magnesium sulfate in a single dose two or three days before operation, followed by colonic irrigation bidaily, and a low residue diet was given for this short preoperative period.

This series of primary resections is too small to present in a statistical manner. The ages varied from 40 to 75 years. There were 8 males and 5 females. Only two patients gave a history of melena. The most striking symptom was abdominal pain which was present in 10

patients Six patients had lost a large amount of weight and one had a severe secondary anemia Eight patients had a palpable mass in the right side Three of the resections were done without hope of cure 2 patients having liver metastases and 1 patient invasion of the duodenum

All patients survived operation there being no operative mortality One developed an abscess in the right lower quadrant which was drained extraperitoneally and 1 patient 75 years of age had a wound separation with secondary closure The hospital stay was definitely shorter than after the modified Mikulicz resections for which two hospital admissions were required and for the primary resections varied from seventeen to twenty six days including the period of preoperative preparation Early ambulation was not practiced in this group most of them being out of bed on the tenth to twelfth day

During 1945 we have continued to employ the modified Mikulicz type of operation for carcinoma of the left half of the transverse colon, splenic flexure descending colon and upper sigmoid Similarly we have utilized the same operation in the right colon for less favorable lesions with obstruction since it enables immediate decompression of the proximal loop at the time of the resection We are continuing to use this procedure for most patients having regional enteritis or regional cicatrizing colitis and for those with segmental ulcerative colitis since we feel that an intraperitoneal anastomosis for these cases carries an additional risk A more frequent employment of primary resection can no doubt be done with the additional aids for increased safety It is only fair for a proper evaluation of the two methods that results be reported which include the total number of cases seen and the number submitted to resection as well as mortality figures If the primary resection is done for favorable cases and the exteriorization principle utilized under less favorable circumstances the mortality rates for the two groups cannot fairly be compared

SUMMARY

During 1945 84 patients with carcinoma of the colon were operated upon at the Lahey Clinic Seventy seven had resections while 7 had some palliative procedure without removal of the growth Sixty two patients were operated upon by the modified Mikulicz procedure in two stages Two patients had a two stage resection consisting of preliminary anastomosis followed by resection Thirteen primary resections of the right colon were performed There was no operative mortality following primary resection

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A DISCUSSION OF THE MODIFIED MIKULICZ OPERATION FOR CARCINOMA OF THE COLON AND ITS TECHNIC

FRANK H. LAHEY

THERE probably has been no commonly used operation about which more misstatements have been made and more misunderstandings have occurred than the operation which we have employed and have termed the modified Mikulicz operation. It has been variously described by others as the exclusion operation and the Paul operation, but we have adhered to the term Mikulicz because of the fact that it was Mikulicz who first described the double barreled tube by which exteriorization was accomplished and secondary closure and anastomosis performed.

The original Mikulicz operation if applied today would be open to many criticisms which would at once be evident. In the original Mikulicz operation the tumor was left in place, the two loops of bowel sutured together implanted in the wound. This resulted in several very undesirable features. There was frequent implantation of the carcinoma in the wound, there was always an inadequate removal of bowel tube and adjacent mesenteric roots, and there were frequent situations, I am sure, in which adequate mobilization was not possible so that the tumor could be brought well outside the abdominal wall.

Radicalness of the Modified Mikulicz Procedure—Based upon the lack of experience and understanding of the radical procedure which I first wrote¹ about in 1932, one frequently hears the statement that with the Mikulicz operation an adequate amount of bowel and mesentery cannot be removed, that so much bowel must be preserved to bring the loops together that it interferes with the radicalness of the procedure.

All of these conceptions and criticisms of the modified Mikulicz procedure as we have practiced it are untrue. In fact, it is quite the reverse. In most of the Mikulicz procedures which we have employed the extent of removal of bowel and mesentery is greater than frequently is the case with the excisions which go with primary anastomosis. For example, in a carcinoma of the hepatic flexure we have never considered any resection by the modified Mikulicz plan adequately radical unless it included all of the ascending colon and all of the transverse colon together with all of its adjacent mesentery down to its very mesenteric roots at the origin of the mesenteric vessels and well over to where the transverse colon becomes the splenic flexure (Figs. 273 and 274). By placing the ileum beside the remain-

ing portion of the colon, any amount of colon can be removed and a satisfactory Mikulicz established by removing any or all of the colon from the head of the cecum down to the lowest portion of the sigmoid (Fig 275)

We have never had any arguments with the advocates of removal of the lesion and immediate anastomosis, end to end, side to end, or side to side. In our opinion all discussions as to whether or not one employs primary anastomosis or the modified Mikulicz procedure as we have described it are not concerned with the radicalness but merely with the matter of how the anastomosis is done, either by the primary or by the delayed two stage exclusion plan.

We do not wish to argue with anyone against primary anastomosis. No one method either the Mikulicz or primary anastomosis, is the best for everyone and for every case. There will be many variable features in each case as relates to the lesion, the complications, the extent, the degree of operability, the patient's condition and many other factors. We can only say that with a mortality now of 27 per cent in resections of the colon associated with an operability rate of 83 per cent, we have a feeling of safety and comfort with this type of resection. A great deal of this may undoubtedly be due to our familiarity with it, to our experience in making the Mikulicz and our experience with its management. We have employed this procedure with equal satisfaction in cases of ulcerative colitis, segmental in character, regional ileitis in which we have always resected the ascending colon in addition to the terminal ileum to the cases of polyposis and to the cases of carcinoma of the colon.

Advantages—Some of the reasons for our liking and continuing to employ this operative procedure are as follows. With the two limbs approximated and the ends exteriorized we have a very comfortable feeling of safety about this procedure. We feel additionally safe because of the fact that we can immediately introduce a decompressing tube into the proximal end of the Mikulicz ileum if it be ileum to colon or the proximal colon if it be colon to colon, with the opportunity to irrigate and decompress immediately. We have found the ability to endoscope the remaining loops of bowel for the possibility of adjacent polyps of additional value in these cases and we must admit that doing these cases in the numbers which we do we have in the past years overlooked such adjacent polyps that by this procedure can be removed by fulguration.

We would not have anyone believe that we are stubbornly wedded to this procedure and have, when there have been metastases in the liver and a palliative resection done, employed ileocolostomy at the time of the resection rather than a Mikulicz procedure.

We have never employed a Mikulicz procedure when a palliative resection has been done because we believe that the patient should

then be provided with every day of comfort possible in the limited number of months or weeks available to him. For that reason, in this type of palliative operation we have always employed anastomosis of the ileum to that portion of the colon beyond its resected segment.

In many patients who are thin, whose colons are not bedecked by heavy fat tabs and their epiploic appendages, end to end anastomosis of the colon can be done particularly after proper colon preparation with a high degree of safety. We believe, however, that there are many patients with fat mesenteries, with fatty epiploic appendages and many more with associated diverticula running up and down the colon in whom accurate anastomoses are difficult, if not impossible, in terms of a high degree of safety. The Mikulicz operation has appealed to us because it is applicable to any type of colon no matter how fat the patient or how numerous the fatty epiploic appendages or how fat filled the mesentery is or how inflamed the colon is. We have preferred an operative procedure which in our hands has been applicable to every patient with equal safety to one which is applicable to some with greater safety than to others.

Rules for the Modified Mikulicz Procedure.—There are a few sound rules regarding the Mikulicz procedure about which I would like to write. From our experience, we advise that all Mikulicz procedures be done through either a right or left rectus incision. This permits up and down exposure and allows good implantation of the ends of the exteriorized two loops of bowel between muscle bundles and it permits adequate approach to either colon from these longitudinal incisions. From a right rectus incision, the left colon may be adequately and safely mobilized, from a left rectus incision the right colon may be adequately mobilized.

There are two types of incisions through which Mikulicz procedures should not be done. One is the McBurney intramuscular incision limiting the extent of exposure and not permitting as good implantation of the exteriorized bowel ends as will the right or left rectus incision. Second, the Mikulicz procedure should not be done through the midline particularly in the epigastrium. There will always be a tendency to do Mikulicz resection if the method is employed for lesions in the midtransverse colon. Due to the fact that the *transversus abdominis* muscles tend to pull the abdominal wall apart in the midline, the implantation of the two exteriorized loops of colon in the midline will very frequently result in hernia. A Mikulicz implanted here is also very likely to be followed by a hernia when the second stage turn in of the ends is accomplished.

When there has been a previous operation on the right colon as for an abscess about an inflamed carcinoma the resection can be done through the right rectus incision but will frequently include the ascending colon, hepatic flexure and that portion of the transverse

colon next to the splenic flexure. In such an instance it is much better after approximating the ileum to the distal transverse colon to implant both ends through a counter incision high in the left rectus on the opposite side so that it will be in a clean undrained wound.

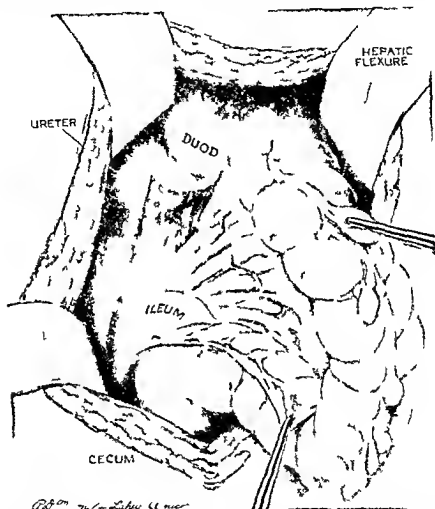


Fig 273—In this illustration the carcinoma of the right colon is not shown. The entire descending colon, cecum and ileum have been mobilized to the left; the hepatic flexure has been freed and turned down; the ureter is visualized as it runs into the kidney pelvis and the kidney is shown as a shadow where the ureter disappears beneath its lower edge. The retroperitoneal duodenum is shown at the upper angle of the wound ready to be mobilized from the root of the mesentery so that a wide dissection of mesenteric root can be made.

When there has been a previous operation or two previous operations for example on the right side with indurated scars over the right colon it is frequently wise although the original scars may have been excised to implant the two ends to be exteriorized (the transverse colon and approximated terminal ileum) through a counter incision high in the left rectus. If one does not do this it is often im-

possible or unsatisfactory to close the scarred abdominal wall and rectus adequately about the two exteriorized ends (colon and ileum)

When there has been an abscess cavity it is frequently possible as I have described and illustrated in an article published in 1939 to drain the abscess cut off the transverse colon and ileum between clamps leave the root of the mesentery of the affected portion of the colon intact and attached to the colon suture the "V" root defect together do the Mikulicz transplant it to the opposite side of the abdomen and then in the segregated right section of the abdomen remove the infected colon pack the abscess cavity and suture the wound about a drain This accomplishes the implantation of the Mikulicz ends in a clean portion of the abdomen and permits packing the introduction of sulfanilamide and drainage through the original right rectus incision

Application of the Method at Different Levels—The plan of modified Mikulicz resections which we have advocated has been published several times It is in *Surgical Practice of the Lahey Clinic* and in numerous journals Its success and the radicalness for that matter of any operation on the colon for removal of a malignant lesion depends largely upon how freely the colon is mobilized—the segments of bowel proximal and distal to the lesion how freely the mesentery adjacent to the malignant lesion is mobilized and then removed

For purposes of completeness I would like to discuss the method employed for lesions at different levels In lesions of the *right colon* the *cecum*, *ascending colon* or *hepatic flexure* the right rectus incision is employed the colon is mobilized by splitting its lateral parietal peritoneal attachments until it is completely free and hangs by its roots in the midline It is freed down to the inferior vena cava and aorta The mesentery of the ileum as it swings over the rim of the pelvis is mobilized and the ureter is demonstrated as it passes behind it The ureter is followed carefully up to the point where it passes behind the retrocolic duodenum to enter the pelvis of the kidney The perirenal fat enclosed in its renal fascia is carefully wiped down to the root of the mesentery of the right colon as is the retrocolic duodenum (Fig. 273)

In resections of the right colon very frequently I have seen with the removal by one stage procedure incomplete mobilization of the retroperitoneal duodenum which is necessary to obtain the most radical removal of the mesentery of this section of the colon

If there is a carcinoma of the hepatic flexure it is not in our opinion adequate to resect that portion of the colon without completely mobilizing the retrocolic duodenum so that it is freed completely down to the place where it passes beneath the mesenteric root to become the jejunum and thus make possible removal of the large gland bearing area of mesentery

It has always been our custom when there is a carcinoma of the cecum, ascending colon or hepatic flexure to remove all of these structures and the transverse colon well past the middle line (Fig. 274), to approximate the terminal ileum to the left transverse colon by the Mikulicz plan after removal of the mesenteric root of all of this structure, that is, the mesentery of the terminal ileum, ascending colon, hepatic flexure and transverse colon up to the point where the approximation of the ileum to the transverse colon is to be made. In



Fig. 274—The hepatic flexure has been completely mobilized and the transverse colon in the direction of the splenic flexure is being separated from the stomach so that in a carcinoma of the ascending colon or hepatic flexure or of the right transverse colon, the ascending colon, hepatic flexure and transverse colon can be removed and the ileum placed beside the transverse colon.

order to approximate the terminal ileum to this portion of the colon it is often necessary to mobilize the splenic flexure in order that enough of the transverse colon can be pulled out of the wound so that an adequate and long Mikulicz approximation of the ileum to the transverse colon can be made, a point which I am sure often is not recognized or successfully employed to make these resections radical.

The mesenteric roots of the two loops of terminal ileum and colon

are carefully approximated, great care being taken to leave no apertures through which internal hernia can occur

So wide and extensive is this removal that it is frequently impossible to peritonealize the space left in the right side by the removal of this colon. It is particularly impossible to peritonealize the right gutter region in the upper portion in the region of the hepatic flexure and when there is the slightest difficulty, in these cases no attempt is made to do so

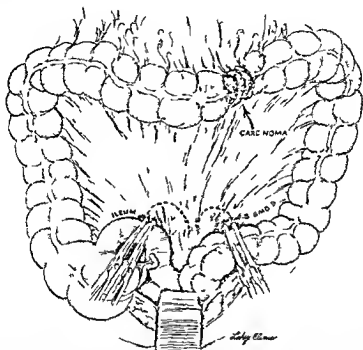


Fig. 275—This illustrates one of the recent cases with an extensive lesion in which total colectomy was done in order to accomplish radical removal of nodes. Note that the Mikulicz procedure lends itself when one wishes to employ it in total colectomy. The dotted lines represent the mesenteric roots to be approximated.

In carcinomas of the splenic flexure it is readily possible to do wide resections by so mobilizing the splenic flexure and the hepatic flexure that that portion of the transverse colon which is to the right of the midline can be brought over against the descending colon to establish a Mikulicz, permitting wide removal of bowel tube together with a wide area of mesenteric root.

As we have previously mentioned it is important in removing a lesion at this level never to excise a "V" of mesenteric root down to the point where the jejunum becomes retroperitoneal. It is here that the parietal peritoneum is delicate, will not hold stitches, and if ap-

proximated, can on coughing, straining or vomiting, later rupture and produce an aperture through which can occur an internal hernia with strangulation. It is in these cases that an apron of peritoneum should be left adjacent to the jejunum to avoid the possibility of this complication.

In carcinomas of the *transverse colon*, resections are made with regard to the point where the carcinoma is as relates to the mid-transverse colon. When the carcinoma is closer to the hepatic flexure,

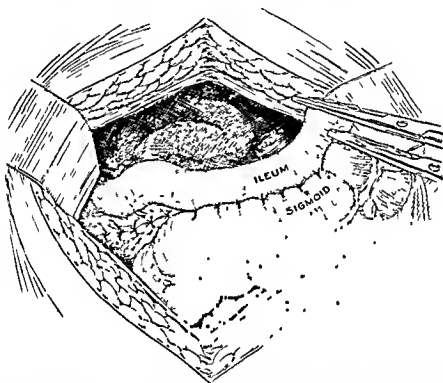
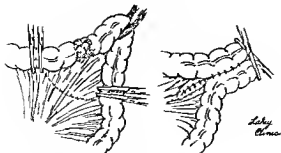


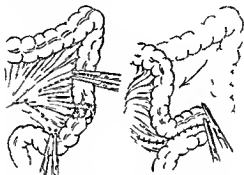
Fig 276.—This is the approximation of the ileum to the sigmoid in the case shown in Figure 275, and demonstrates two things, (1) the method of laying the ileum beside the large bowel in the modified Mikulicz, and (2) the tube of ileum is longer than the tube of colon or sigmoid, devascularized with no blood supply so that a tube or catheter can be inserted in it immediately after it is implanted in the wound

the resection is done through a right rectus incision. When it is close to the splenic flexure it is done through the left rectus incision (Fig 277, a). When it is in the midline, it is done through a left rectus incision in order to remove the ascending colon and hepatic flexure and to mobilize the splenic flexure and to approximate the terminal ileum to a high segment of the descending colon.

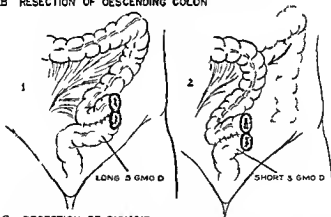
Resections of the *descending colon* by the Mikulicz procedure are again made radical by mobilization of the splenic flexure and mobilization of the sigmoid loop (Fig 277, c). This provides such an ade-



A RESECTION OF SPLENIC FLEXURE



B RESECTION OF DESCENDING COLON



C RESECTION OF SIGMOID

Fig 277 -A, This shows the method of resecting the splenic flexure. Note the dotted line showing that the mesentery is not taken out as a V in this region because of the delicacy of the parietal peritoneum in the jejunal fossa. Note that this leaves a circular apron of undisturbed mesenteric root which is so thin that it possesses very few nodes and in addition protects the mesenteric root against later rupture and possible internal hernia.

B, The method of resecting lesions of the descending colon by the Mikulicz plan whereby the splenic flexure is mobilized and lowered in order to provide radical removal and two good loops for the Mikulicz double barreled enterostomy.

In this illustration unlike the mesenteric removal in a "V" of mesentery is taken out down to the root of the mesentery. Note also that again the proximal

quate tube of relaxed bowel above and below the lesion that long loops of colon adjacent to the lesion can be removed, together with wide areas of mesenteric root in order to get out the largest possible number of adjacent lymph nodes

Resections of the sigmoid by the Mikulicz procedure, when the lesion is in the midsigmoid, are the simplest of all modified Mikulicz removals. Because of the fact that the sigmoid is frequently lax, can readily be mobilized, and has a good blood supply, this segment of bowel lends itself well to the application of the modified Mikulicz operation (Fig 277, c)

When the lesion is in the lower loop of the sigmoid where an inadequate amount of bowel tube remains below for the application of the modified Mikulicz procedure, it is our opinion that in such cases, the abdominosacral type of operation is to be preferred rather than any type of resection with pelvic anastomosis

General Aims and Rules.—In resections of the colon for carcinoma we are anxious to accomplish three things (1) a wide removal of bowel proximal and distal to the lesion, (2) the removal of the greatest number of adjacent lymph nodes in the mesentery of that section of the bowel involved, and (3) the removal of the greatest number of vessels adjacent to the involved section of bowel above and below

We have never felt any responsibility to sacrifice radicalness of the removal of the lesion in terms of endeavoring to preserve the anal sphincter. In recently discussing pelvic anastomoses after resections of lesions of the colon I said that I firmly believe that aggressiveness of approach and radicalness of removal by far take precedence over any sentiment concerning the preservation of the sphincter

Colostomy is today such a different operation than it was in years gone by and its management so much more satisfactory that I feel very strongly that decisions are being made today against such radical operations that are based upon unsound advice and conclusions as to what colostomy is as concerns the patient's ability to be active, to work, to play and to enjoy life. Too few people and doctors are aware that the colostomy of today and its management after the lesion has been removed are most satisfactory and quite different than the colostomy and its management of years gone by

There are just a few other general rules regarding the Mikulicz procedure. We have no interest in a Mikulicz so done that after the spur

loop of the colon of the Mikulicz anastomosis is longer than the distal one when it is implanted into the wound to allow for the introduction of a tube

C-1, This shows the ease with which Mikulicz resection and approximation of the two loops can be done in a patient with a redundant sigmoid

C-2 This illustrates again the advantage when the sigmoid is short of mobilizing the splenic flexure to obtain a longer proximal loop

is cut down they will close themselves. We pull good segments of bowel tube well outside the abdominal wall so that there will be plenty of tube to free and to turn in by three rows of sutures. With a good tube of bowel well implanted outside the abdominal wall in occasional patients in whom with any operation wound infections will occur there will be sufficient walling off and ability to control the discharge so that a fatality will not result. If the end is implanted deep in the wound and infection occurs there can be retraction of the two ends into the abdominal cavity with resulting peritonitis and a fatality.

We have been very careful in closing abdominal walls about implanted Mikulicz operations never to pass a stitch through the colon wall. We have depended solely upon implantation to hold the two loops of bowel within the abdominal wall. It is a delicate balance between making the closure about the implanted bowel too tight and yet not so loose that a loop of small intestine will come out.

Second Stage Closure—The second stage closure of the Mikulicz operation has in our hands been 100 per cent successful as concerns persistent fistulas. There are in existence as far as I know, no second stage Mikulicz procedures which are not permanently closed with dry wounds and no discharge.

We have delayed in all of our cases for two months before closing the enterostomy of the second stage Mikulicz. In our early experience we tried closing these enterostomies at an earlier date but found the wound indurated, often with small pockets of creamy material, the peritoneum not firmly attached to the loops of bowel, the wound still indurated, and a situation which was not entirely satisfactory.

We have arbitrarily set a minimum time of two months to elapse before a second stage Mikulicz closure of the enterostomy is attempted. There are just a few principles involved in this procedure which go to make it a success. The implanted tube of bowel in the abdominal wall must be completely mobilized down to its attachment either to the fascia in fat people or to the peritoneum in thin ones or moderately fat patients. Every trib of fatty mesentery and epiploic appendage must be carefully removed. The adherent and indurated circle of skin into which the Mikulicz has been implanted together with the reduplicated fold at the terminal ends of the implanted loops of bowel must be carefully freed and cut away. When this operation is properly done the common tube of two loops of colon or ileum and colon are completely soft and so freed that their ends can be accurately inverted with an in-out and over catgut stitch which can be reinforced with another mattress catgut stitch which buries it. It can be reduced into the abdomen, two small sections of Penrose drain placed beneath the fascia and the muscle and fascia closed about the wound (Fig. 278).

SKIN INCISION AROUND COLOSTOMY

SEPARING FAT AND SKIN
FROM TUBE OF BOWEL

SUTURES INVERTING COLOSTOMY STARTED

P.B.M.
Lahay, Clinician

Fig 278—*Top*, The incision in the skin is shown about a double barreled colostomy for a Mikulicz which has now been converted into one tube

Center, This illustrates the careful preparation of all epiploic appendages, fat tabs, mesentery and the adherent and scarred skin as it is attached about the edge of the colostomy. It will be found, when the skin is carefully detached from the puckered bowel which is implanted in it, that at least an extra inch of bowel tube will be obtained

Bottom, This diagrammatically illustrates the tube completely freed and being inverted with beginning catgut stitches. It will be completely inverted by three rows until it is reduced within the abdomen, and the muscle, fascia and skin, with a rubber dam in each end, closed over it.

We have learned that when patients have been sent home after their first stage Mikulicz procedure, with the spur well cut down and returned for the second stage closure, if the finger is put in the

wound the spur will not infrequently be found to have risen considerably due to the organization of the scar where the Ochsner clamp was applied to the spur. We have made it a principle never to close second stage Mikulicz operations until we were sure that the spur between the two sections was adequately severed and when it is not before closing we have applied another Ochsner clamp for three or four days until the spur was adequately severed and then turned in the exteriorized end of bowel.

In spite of the fact that these wounds are often contaminated with feces at the time that this turn in is done due I am sure to the secondary local immunity which they have acquired there has never been serious wound infection. They will occasionally following the removal of the two rubber dam drains placed at the upper and lower ends of the wound discharge for a short period of time but they have all ultimately healed and a great majority heal by first intention.

CONCLUSIONS

The modified Mikulicz operation which we have practiced and described is as radical if not more so than most primary resections with anastomosis.

It presents no limitations as to the extent of colon or mesentery which can be removed with its employment.

It is applicable to any segment of the colon down to the lower sigmoid.

It permits immediate decompression of the bowel as soon as the operation is completed.

With it our operability rate is 83 per cent and mortality is 2.7 per cent.

It is unjustifiable in palliative resections when patients have the lesion removed in the presence of a limited number of metastases in the liver because it complicates and makes less satisfactory the limited period of time available to the patient.

Some of the steps necessary for its successful accomplishment are discussed.

Its limitations in the low sigmoid are also discussed.

Some of the steps necessary for the successful management of second stage closure are discussed as well as the time period which we have found most satisfactory to wait between the first and second stages of this operation.

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AN UNUSUAL COMPLICATION OF THE MIKULICZ TYPE OF RESECTION

RICHARD B. CATTELL AND MARK L. WELCH

THE complications which may follow Mikulicz resection for both inflammatory and malignant disease of the colon have been reported previously.¹ We wish to report a case in which a large abdominal tumor, simulating recurrent malignancy, developed in a patient who previously had undergone a Mikulicz resection for carcinoma of the sigmoid. This tumor was discovered at a routine check up examination in an asymptomatic patient, fifteen months after operation. This unusual complication has occurred only twice in over 450 modified Mikulicz resections performed in this Clinic since 1930. It is important to understand the principles of the technic of the modified Mikulicz operation which have been reported elsewhere^{2, 4} to understand the occurrence of this complication.

REPORT OF CASE

A white male school teacher, aged 48 years, was first seen in the Clinic in May 1940 because of rectal bleeding of six months' duration. Except for mild attacks of indigestion following the eating of certain foods, his general health had been good. He had passed bright red blood on several occasions following a bowel movement. These attacks were painless and not associated with constipation or diarrhea.

Physical examination failed to reveal any abnormality. Sigmoidoscopic examination was normal except for two small bleeding internal hemorrhoids. A complete gastrointestinal study, including a barium enema, was negative. A diagnosis was made of bleeding internal hemorrhoids and he was treated with injections of a sclerosing solution at weekly intervals for four weeks, with relief of symptoms.

On April 15, 1944, four years after the patient's first visit to the Clinic, he was readmitted complaining of rectal bleeding of three months' duration. He had passed both dark and bright red blood and had noticed some difficulty in having his usual daily bowel movement. During the past few months he had lost 20 pounds in weight.

Examination revealed that the patient was well developed and well nourished, weighing 170 pounds. He was not acutely ill. Temperature, pulse, respiration and blood pressure were normal. Physical examination was negative except for very slight tenderness in the left lower quadrant of the abdomen. No mass could be palpated. Digital examination was normal.

exa

incl

was negative. Roentgenograms of the colon following a barium enema disclosed a partially obstructing lesion in the descending colon which the roentgenologist diagnosed as a new growth.

The patient was admitted to the New England Baptist Hospital and, after the usual preoperative preparation, was operated on May 25, 1944. Under ponto

caine-dextrose spinal anesthesia the abdomen was opened through a left rectus muscle-splitting incision. The liver, stomach, pancreas and small bowel were found to be normal. A hard, annular, obstructing tumor, about 3 inches in length, was found encircling the upper sigmoid colon. A few palpable nodes were present in the mesosigmoid. A modified Mikulicz resection was done, removing the lesion and a portion of the descending and sigmoid colon, including a generous V-shaped segment of the mesentery.

Convalescence was uneventful. The colostomy spur was divided by crushing clamps, beginning on the fifth postoperative day. The patient was discharged on the sixteenth day after operation to return in six weeks for closure of the colostomy.

The microscopic diagnosis was adenocarcinoma of the sigmoid. The lymph nodes were negative.

The patient returned to the Clinic at intervals of three months for a routine check-up examination. At each visit he had no complaints, was gaining weight and "felt fine."

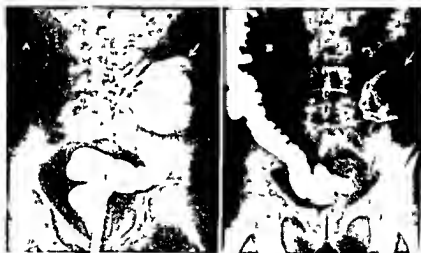


Fig. 279—*a*, Barium filled colon and Mikulicz cap fifteen months following resection for carcinoma of the sigmoid. *b*, After evacuation of barium, demonstrating a barium covered intraluminal mass which at operation proved to be a fecal impaction.

On November 24, 1945, fifteen months after operation the patient reported for examination. Again he had no complaints. Inspection of the abdomen disclosed a slight bulge in the central portion of the scar. On deep palpation of the abdomen a mass, about 8 cm. in diameter could be outlined in the region of the scar. It was firm, not tender and seemed to be attached to the posterior abdominal wall. Because of a very thick abdominal wall the patient was not aware of its presence. Laboratory studies of the blood and urine were negative. The mass

was normal (Fig. 279). A diagnosis was made of fecal impaction in the cap of the Mikulicz colostomy. We could not be sure, however, that this was not associated with early recurrent malignant disease, therefore, operation was advised.

On December 27, 1945 under pontocaine dextrose spinal anesthesia, the old

operative incision was explored. The scar was excised and the rectus sheath and muscle were dissected free exposing the Mikulicz cap. After further freeing the cap which was quite redundant it was entered through a longitudinal incision. It was filled with a mass of inspissated feces about 14 cm in diameter. There was no evidence of recurrent malignancy. After the mass was delivered through the opening the redundant portion of the cap was excised. The bowel was closed transversely with an inverting Connell suture which was returned to its starting point as a running Lembert stitch. The peritoneal cavity was not entered. A small soft rubber drain was inserted to the bowel and the abdomen closed in layers in the usual manner.

Convalescence was uneventful the drain was removed on the fifth and the sutures were removed on the seventh postoperative days. The wound healed by primary intention and the patient was discharged nine days after operation. He has remained well without recurrence of the mass (Fig 280).



Fig 280—*a* Barium filled colon three months following removal of fecal impaction from Mikulicz cap *b* After evacuation of barium

COMMENT

The diagnosis of any abdominal tumor particularly following operation, may be difficult. In this case the patient was asymptomatic and gaining weight which is of importance in distinguishing this lesion from recurrent malignancy at the site of resection. Patients who have large segments of the bowel removed usually have frequent stools for a time and it is not uncommon for them to have two stools a day for the remainder of their life. Any alteration in the character or number of daily stools after this new routine has been established should be looked upon with suspicion. In early recurrent malignant disease at the site of resection the patient will complain of mild obstructive symptoms. Although a mass or indurated area may or may not be palpable these patients usually complain of constipation.

abdominal cramps and mild distention. Diarrhea is the exception but may be present. Later melena and weight loss may occur.

In contrast to this case a white man aged 73 years underwent a modified Mikulicz resection in August 1942 for carcinoma of the splenic flexure. The microscopic diagnosis was adenocarcinoma. Eight lymph nodes were reported to be negative. He returned in November 1945 three years and two months following resection complaining of constipation and occasional abdominal cramps. A mass was palpable in the right upper quadrant of the abdomen. A roentgenogram after a barium enema (Fig. 281) revealed a partially obstructing lesion in the proximal transverse colon. At laparotomy two lesions were found: an ulcerating tumor in the transverse colon just proximal to

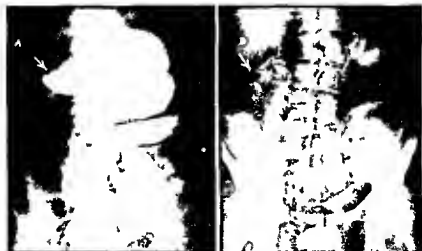


Fig. 281—*a* Colon three years and two months following Mikulicz resection for carcinoma of the splenic flexure. *b* Partially obstructing lesion in the proximal transverse colon. At laparotomy two lesions were found: one in the ascending colon and one in the transverse colon.

the site of the previous resection and a polypoid tumor in the ascending colon. The liver and other viscera were grossly normal. Colectomy and a primary end to end anastomosis of the terminal ileum to the sigmoid were done using the Furniss clamp.

It is difficult to distinguish between recurrence at the site of resection and a fecal impaction by roentgenologic examination (Figs. 279 and 281). Even though one may be relatively certain of the diagnosis of fecal impaction, exploratory laparotomy should be carried out as it is impossible to be sure that the mass is not associated with early recurrence.

This complication may be prevented by the removal of the redundant and excess portion of bowel at the time of closure of the

colostomy One is likely to err on the side of leaving an ample amount rather than risk encroaching on the lumen at that point If there is sufficient encroachment of the lumen to result in obstruction, a fecal fistula may result

In constructing the Mikulicz colostomy, two loops of bowel are approximated by two rows of interrupted seromuscular sutures inserted in the longitudinal bands of the colon This forms a double barreled colostomy which should be at least 5 to 6 inches in length The colostomy spur is divided deep which we think is important in preventing reopening of the colostomy following its closure After closure of the colostomy the resulting cup has a wider diameter as visualized in the roentgenogram (Figs 279 and 281)

Early or late recurrence following the modified Mikulicz type of resection has occurred in 45 per cent of our patients who have survived resection This includes those in whom a palliative resection was done Of those followed from five to ten years 55 per cent had no recurrence during the period of observation The possibility of contact recurrence has been eliminated entirely by removal of the lesion at the first stage

SUMMARY

An unusual complication of the Mikulicz resection is reported The diagnosis is discussed briefly A case is reported to illustrate the extra peritoneal management of this complication of the modified Mikulicz resection

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ANURIA AND UREMIA FOLLOWING SURGERY OF THE RIGHT COLON (ILEOSTOMY)

ELAHER C. BARTELS

OPERATION on the right colon which necessitates an ileostomy may lead to a disturbance in salt and water balance of the body which if not prevented may lead to serious consequences. The average un-complicated surgical patient who receives a total fluid intake of 3000 to 3500 cc of which 1000 cc is normal saline solution will have a urine output of 1000 to 1500 cc. Such an intake of fluid and salt permits a normal fluid balance. Since the fluid and sodium chloride loss from an ileostomy might be large this loss must be taken into account when the patient's daily fluid and sodium chloride ration is determined. Each patient must receive a careful day by day evaluation of the total body output of fluid and sodium chlorides when calculating the daily requirement. If this is done there is no need for difficulty ensuing.

To allow water and sodium chloride negativity to continue will lead to a lowering of the blood sodium chlorides, decrease in urine output and then to elevation of the blood nonprotein nitrogen. This may proceed to a state of complete anuria and finally to circulatory collapse and death. Fortunately this condition of extrarenal azotemia is amenable to therapy unless too far advanced, permitting a return of the blood factors and renal function to normal. Therapy consists of the restoration of the lost sodium chloride and water, large amounts of each at times being necessary.

REPORT OF CASE

A woman of 53 years complained of lower abdominal pain of one year's duration. The pain which at first was mild soon became rather sharp, intermittent in type and finally constant, being limited to the right lower quadrant. There was a loss of 19 pounds in weight during the previous six months.

On examination of the abdomen a questionable mass was found in the right lower quadrant. Fluoroscopy of the colon demonstrated an irregularity of the cecum which was interpreted as a carcinoma. The blood studies revealed a moderate anemia; the hemoglobin was 9.9 gm and the red blood cell count 3,880,000. A diagnosis was made of carcinoma of the cecum.

At operation the diagnosis of cecal malignancy was confirmed so a first stage Mikulicz resection of the terminal ileum, cecum, ascending colon and proximal third of the transverse colon was carried out. A glass tube was inserted and sutured into the ileum for continuous decompression.

The patient's postoperative course appeared quite uneventful until the ninth day when vomiting began necessitating gastric drainage. The next day anuria developed and then circulatory collapse followed. At this point specific therapy was instituted with complete recovery. An analysis of the fluid and salt balance during the postoperative period revealed the factors which led to this patient's critical state.

For convenience, the postoperative period can be divided into three parts (Fig 282, *a*, *b* and *c*). Part *a* consists of six days, *b* of three days and *c* of five days. Since accurate figures for the first postoperative day were not available, it is not included in part *a*. In part *a*, covering six days, the total urine output was 5040 cc. and if to this is added the 5965 cc. fluid loss from the ileostomy, the known measurable output was 11,005 cc. If to this is added an estimated daily loss of 1500 cc. of water in vaporization and by perspiration, the total fluid loss during this period was 20,005 cc. Since the total fluid intake was 17,790 cc., the body was dehydrated by 2215 cc. The sodium chloride loss from the ileostomy during this six day period can be approximated as 42 gm. since a previous study¹ showed about 7 gm. of sodium

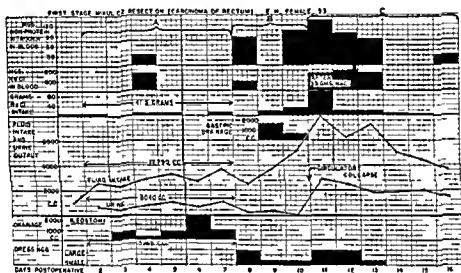


Fig 282—Anuria and uremia in a patient following ileostomy. Fluid and sodium chloride loss led to lowered blood chloride and elevated nonprotein nitrogen. Large amounts of fluid and sodium chloride restored blood chloride and nonprotein nitrogen to normal.

chloride to be present in each 1000 cc. of ileostomy fluid. If to this known sodium chloride loss of 42 gm. is added 45 gm. that was lost in the urine and by perspiration (7.5 gm. per day) the total loss was 87 gm. Since only 41.5 gm. of salt was actually received intravenously, little being given by mouth, the body was depleted of about 40 gm. of sodium chloride. This depletion of sodium chloride plus the negative fluid balance was responsible for the elevated nonprotein nitrogen (82 mg. per cent) and decreased sodium chloride (398 mg per cent) which was noted on the eighth day. These changes took place in spite of a seemingly adequate fluid intake of 3750 cc. and urine output of 1500 cc. on the seventh day.

During the first three days of part *b*, the urine output gradually declined to 240 cc. the first day, 360 cc. the second day and then anuria

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CHRONIC ULCERATIVE COLITIS: DIAGNOSIS AND MEDICAL MANAGEMENT

EVERETT D. KIEFER

ACCURATE diagnosis in chronic ulcerative colitis requires a recognition of the disease in a variety of forms and in varying degrees of severity. The many different manifestations are inherent in the nature



Fig 283—Localized ulcerative colitis involving the rectum and lower sigmoid which appear smooth in outline and somewhat contracted in caliber. The remainder of the colon appears normal. This patient had few systemic symptoms and complained of constipation and blood in the stools. The diagnosis depended largely upon the proctoscopic findings.

of the morbid process, its clinical course and the corresponding changes in anatomy and physiology of the bowel.

Chronic ulcerative colitis may be defined as a chronic disease of unknown etiology in which there is a diffuse inflammatory reaction

volving all coats of the colon and rectum either as a whole or in part, subject to remissions and exacerbations, complicated by varying degrees of sepsis, ulcerations and necrosis of the mucosa and resulting in extensive fibrosis of the entire intestinal wall

Since the disease is a chronic one in which remissions and exacerbations are characteristic, diagnosis includes the recognition of both active and inactive forms of colitis



Fig. 284—Severe, active ulcerative colitis involving the entire colon and rectum. The colon is irritable and does not retain the barium well. Both the caliber and the length of the bowel are reduced. The haustral markings are obliterated by edema. The irregularities and niches in the border of the bowel shadow indicate gross involvement of the mucosa with ulcerations. This patient was severely toxic, had fever, severe diarrhea and blood and pus in the stools.

Active ulcerative colitis may present a diagnostic problem in the initial attack or as a recurrence of a previous episode. Since the severity is so variable it may be a mild colonic or rectal disorder without serious disability, or a severe fulminating disease resulting in early death of the patient.

Inactive colitis may present for diagnosis chronic irreversible organic changes in the lower bowel involving either a limited segment or the entire colon and rectum and at times including the terminal ileum. Ulcerative colitis during remissions of activity may be practically symptomless while in other cases the organic damage suffered by the colon and rectum is so marked and the function of the bowel so altered that chronic invalidism results. All degrees of variation between these extremes are found.



Fig 285—Chronic, severe, inactive ulcerative colitis involving the entire colon and rectum which are contracted both in length and caliber. The haustral markings are obliterated by edema and fibrosis. The outline of the bowel is smooth, indicating fibrosis and atrophy of the mucosa. The ileocecal valve is gaping permitting free flow into the terminal ileum. This patient was a chronic semi invalid with malnutrition and chronic diarrhea. She had no fever and the stools did not contain visible blood.

SYMPTOMATOLOGY

In the milder forms of active ulcerative colitis the outstanding and sometimes the only symptom is a rectal discharge of bloody mucus. There may be more or less tenesmus and diarrhea but often the stools

are normal. In many cases there are little or no systemic effects, the patient is not incapacitated and if adequate diagnostic studies are not employed the true cause of the repeated attacks of rectal discharge may not be suspected.

The well known "textbook picture" of chronic ulcerative colitis is a more severe disease characterized by recurrent and usually protracted periods of severe diarrhea. Gross blood in the stools is a variable feature. In some cases considerable blood is lost in this way while in others there is no visible blood at any time in the course of the disease. Commonly, there are two types of bowel movements. In addition to the usual diarrheal stools consisting of liquid feces with the admixture of more or less blood, there are varying numbers of rectal discharges which consist of mucus, blood and pus. The frequency of these discharges of exudative material is generally directly proportional to the activity of the colitis.

Systemic symptoms are also extremely variable. They arise from disturbances of nutrition, loss of blood and the effects of chronic sepsis.

Consequently, chronic ulcerative colitis may cause retardation of development, weight loss, amenorrhea, avitaminosis, hypoproteinemia and anemia. Fever and leukocytosis frequently occur during the periods of active disease but in some cases they are never observed. The explanation of this variation is probably on the basis of different degrees of secondary infection of the bowel with a variety of different organisms. The frequency of septic skin lesions, infectious arthritis, and perianal abscesses is evidence of the colitis patient's lowered resistance to infection.

The cases of so called "fulminating ulcerative colitis," characterized by severe bloody diarrhea, tenesmus, abdominal pain, toxemia and fever, are those in which the factor of acute sepsis is predominant. Gross destruction of the colonic mucosa, hemorrhages, perforations and toxic ileus are responsible for the high mortality. This form of colitis may occur as the first attack but often represents an acute exacerbation of a colitis which has been present for a time.

Chronic ulcerative colitis is, in general, a disease of young adults and children. The most severe cases have their onset in the second decade or in the early twenties. This characteristic is so striking that when the onset of symptoms occurs after the age of forty the diagnosis of ulcerative colitis should be viewed with skepticism until extensive diagnostic studies have ruled out the intestinal diseases more common at this age.

DIAGNOSIS

From the standpoint of diagnosis the review of symptomatology may be simplified to the dictum that any case of persistent diarrhea or any case of a discharge of blood or pus from the rectum may be one of ulcerative colitis.

The diagnosis depends entirely upon the demonstration of the characteristic changes in the colon and rectum, which can be done by the use of the proctosigmoidoscope or the roentgenogram or both. Both methods of examination should be employed in all cases because only by the correlation of the data obtained in both procedures can a satisfactory estimate of the extent and activity of the disease be made.

In a large majority of cases of ulcerative colitis the rectum and sigmoid are involved so that the typical diagnostic changes in the mucosa can be directly viewed through the proctoscope. The characteristic inflammation of the mucosa in ulcerative colitis has a diffuse distribution so that there are no areas of normal mucosa to be seen in the segment involved. The initial change appears to be one of congestion which may be so marked that small hemorrhages occur in the mucosa. Exudation from the inflamed surfaces produces a coating consisting of mucus, pus and blood. Edema of the wall of the rectum and sigmoid produces narrowing of the lumen and thickening of the rectal valves. In the acute fulminating cases areas of necrosis and destruction of the mucosa may be seen, but discrete ulcerations are not typical of idiopathic ulcerative colitis. Inspection of the mucosa during remissions of activity shows less congestion, edema and exudation. The surface is roughened and granular because of fibrous scarring in the mucosa. Easy bleeding with the slightest touch is characteristic.

Roentgenology—Although the diagnosis of ulcerative colitis is often possible from the proctoscopic examination alone, it is only by the roentgenogram that the extent of involvement of the colon can be determined. In colitis, changes from the normal roentgenologic appearance of the colon are the result of irritation of the organ and edema of the wall of the bowel, with obliteration of haustral markings, loss of flexibility, narrowing of the lumen and coarsening of the mucosal pattern. The inevitable fibrosis of the bowel wall produces a permanent narrowing and shortening of the large intestine as well as rigidity, which may be marked in degree.

Differential Diagnosis.—The differential diagnosis of ulcerative colitis involves consideration of cancer of the rectum and colon, bacillary dysentery, amebic dysentery, tuberculous enterocolitis, lympho granuloma inguinale and regional ileitis.

Although *cancer of the large bowel* may produce similar symptoms, it may be suspected when the onset occurs in later life. A diagnostic study with both the roentgenogram and the proctoscope reveals findings so different that differentiation is not difficult.

Bacillary dysentery is ordinarily an acute form of colitis which occurs in epidemics as a result of an infection with a specific organism which can be identified by culture. In certain instances a chronic form of colitis has followed an attack of acute bacillary dysentery which is indistinguishable from chronic ulcerative colitis.

Chronic amebic dysentery rarely produces the marked and extensive roentgenologic changes in the bowel as does ulcerative colitis. The amebic ulcerations observed proctoscopically are distinct ulcerations with surrounding mucosa which is comparatively normal. The diagnosis of amebic colitis depends upon the finding of amebae or amebic cysts.

Tuberculous enterocolitis may be identified by its characteristic location involving the terminal ileum and proximal colon and by its association with open pulmonary tuberculosis.

Lymphopathica venereum characteristically involves the rectum and surrounding tissues producing marked granulomatous changes without affecting the colon. The Frei test is usually positive in this disease.

Regional ileitis may produce chronic diarrhea, anemia and systemic effect similar to that seen in ulcerative colitis. The proctoscopic examination is negative and roentgenologic studies of the gastrointestinal tract show the involvement of the ileum instead of the colon.

MANAGEMENT

The one outstanding fact concerning the treatment of chronic ulcerative colitis is that as yet there is no specific cure. Medical management therefore consists of general supportive measures which may permit the natural development of a prolonged or indefinite remission. It is extremely doubtful if any well established case of ulcerative colitis can ever be regarded as cured without the complete removal of the colon and rectum.

The measures used in the treatment of this disease may be classified as (1) control of diarrhea (2) correction of nutritional disturbances (3) correction of the effects of blood loss (4) control of sepsis (5) nonspecific therapy and (6) psychotherapy.

Control of Diarrhea—If the colitis is severe and active complete control of the diarrhea is practically impossible. It is desirable however to reduce the number of stools to a minimum.

The diet should consist of foods which have a minimal stimulating effect upon peristalsis as well as a low indigestible residue. Highly seasoned food, ice cold food or drink and excessive quantities of fluid are to be avoided.

Certain inert substances such as bismuth kaolin, aluminum hydroxide and calcium phosphate tend to protect the surface of the bowel, give greater consistency to the stools and possibly have some favorable absorptive properties for intestinal bacteria and toxic substances. A heaping teaspoonful of bismuth subcarbonate or kaolin every two hours may be of benefit but these substances increase the bulk of the stools and do not always produce the desired effect upon the diarrhea. Their use therefore must be regulated for the individual case.

The effectiveness of antispasmodics, including those acting upon smooth muscle as well as those affecting the parasympathetic nerve endings, is difficult to evaluate. Certainly, the ordinary use of atropine or belladonna has no obvious effect. In my experience, from 1 to 1½ grain doses of papaverine every four hours are well tolerated and appear to be effective in relieving abdominal cramps and to some extent reduce the number of stools.

Deodorized tincture of opium (10 minims every four hours) will usually reduce the number of stools temporarily. Larger doses may stop the diarrhea but this may be accompanied by an increase in general toxicity, so it is questionable if it is desirable to stop the free drainage of the bowel. The continued use of opium is to be avoided in chronic cases because of the tendency to addiction.

In many instances a reduction in the number of bowel movements may be obtained by the use of sedatives. Phenobarbital in ½ grain doses three or four times daily is often effective.

Treatment of Malnutrition.—Nutritional disorders are common and usually severe in ulcerative colitis, and their treatment is of first importance in bringing about a remission. The diet should be as liberal as possible consistent with reasonable control of the diarrhea. It should have an adequate caloric value because the disease is a chronic one and the food intake must be supported through a long period of difficult nutrition. There is considerable loss of plasma protein in the exudate from the bowel and the frequent finding of hypoproteinemia is an indication for a high protein diet.

In cases of active colitis and severe diarrhea the following foods may be used:

Meats Beef, lamb, liver, bacon, chicken, fish (twice daily)

In cases in which the diarrhea has subsided, the following foods may be gradually added:

Cereals Oatmeal, corn flakes

Vegetables Lettuce, celery, string beans, peas, asparagus, carrots, beets, cauliflower

Desserts Cooked or canned fruit

Beverages Coffee, orange juice (in limited quantities)

Raw fruits Raw, ripe banana and scraped raw apple may be tried

Vitamin deficiency is a frequently observed complication of ulcerative colitis. The intake of these essential food factors is reduced by the anorexia which accompanies the disease and by the limitation of

the diet in an effort to control diarrhea. The factor of poor absorption of vitamins due to hypermotility is probably of equal importance.

Supplemental vitamin administration is indicated therefore in practically all cases of ulcerative colitis except for those patients who are in a remission and are able to eat a liberal diet. As a general guide to vitamin therapy the following table of minimum daily therapeutic doses published by Jolliffe may be followed.

Vitamin	Moderate Deficiencies	Severe Deficiencies
Vitamin A	25 000 units	50 000 units
Vitamin D	1 000 units	2 000 units
Thiamine hydrochloride	5 mg	10 mg
Riboflavin	5 mg	10 mg
Niacinamide	150 mg	300 mg
Ascorbic acid	150 mg	300 mg

In severely ill toxic patients larger doses of the water soluble vitamins should be given parenterally.

Treatment of Blood Loss—The anemia of ulcerative colitis is caused by the considerable loss of blood in the stools and by inadequate intake and absorption of blood forming constituents of the diet.

Blood transfusions constitute the most effective and most direct attack upon the severe anemias and the hypoproteinemia which is often present. Multiple transfusions until the blood reaches a normal range are frequently helpful in bringing about control of the active symptoms.

Iron administration is indicated but often is not well tolerated because of increased diarrhea. Ferrous sulfate and ferrous gluconate in doses of from 3 to 6 grains three times a day should be tried.

Treatment of Sepsis—Fever in ulcerative colitis is always a serious sign. It usually indicates activity of the colitis with more or less secondary invasion of the diseased bowel wall by a variety of organisms which are present in the lumen.

Sulfonamide therapy in ulcerative colitis has shown variable results. There seems to be little to indicate that there is any effect upon the primary cause of the disease but there is probably considerable value in the bacteriostatic effect of the sulfonamides on the bacteria in the lumen as well as those which secondarily invade the mucosa.

In patients who run a septic course the use of a soluble sulfonamide such as sulfadiazine (1 gm every four hours) is indicated in an effort to reach the invading organisms through an adequate concentration of the drug in the blood. When soluble drugs are used it is necessary to insure an adequate urine output by forcing fluids by mouth and administering additional fluids by vein.

The poorly soluble drugs such as sulfaguandine and succinylsul

athiazole may be used in afebrile cases to reduce bacterial growth within the bowel. In some cases the diarrhea may be lessened but the results are so variable and unpredictable that the value of the drugs is questionable. Recently, Streicher has reported good clinical results from the use of phthalylsulfathiazole, another poorly soluble sulfonamide.

In general, the few reports on the use of penicillin in ulcerative colitis have not been encouraging. Streptomycin, a newcomer in the field of antibiotic therapy, has not been tried sufficiently. It is probable that the antibiotics, like the sulfonamides, will be found to have no curative effect upon the colitis, but that in some cases there will be a favorable clinical effect apparently due to action upon secondary infection.

In the so-called "fulminating" ulcerative colitis, severe sepsis is the outstanding clinical feature. It may be uncontrollable and rapidly fatal. When sepsis proves intractable to medical measures, ileostomy is indicated. In the majority of cases the clinical improvement attendant to putting the colon at rest is striking provided the ileostomy is done before the patient is moribund. Experience at this Clinic has led to the belief that in cases of severe toxicity with a spiking type of temperature curve, rising pulse rate and showing indefinite response to chemotherapy and supporting measures, the deferment of ileostomy for more than a week is extremely dangerous. Although no standard rule can be laid down that is applicable to all cases, comparatively early ileostomy will definitely lower the mortality rate.

Nonspecific Therapy.—Fever induced by injections of nonspecific foreign protein has been observed to have a favorable effect upon the course of some cases of ulcerative colitis. Intravenous injections of graduated doses of typhoid vaccine constitute the method usually employed. The mechanism by which clinical improvement is brought about is not clear but apparently there is mobilization of bodily resistance that sometimes results in a remission of the colitis. This method of treatment is particularly indicated in afebrile cases which run a chronic indolent course and show little tendency to get either worse or better with the usual supportive treatment. Although nonspecific vaccine therapy apparently has some therapeutic usefulness it cannot be considered a cure of ulcerative colitis.

Psychotherapy.—Practically all writers upon the subject of psychosomatic medicine include chronic ulcerative colitis as an example of psychosomatic disease. Certainly, the personality pattern is fully as constant in this disease as in any other organic condition thought to be initiated by nervous factors. In a large number of cases some psychic or emotional trauma is associated with the onset of colitis and anyone treating patients with this disease is impressed with the importance of emotional factors in the control of symptoms. While it is

doubtful that once the colitis is well established any amount of psychotherapy will bring about a complete return to normal, it is certainly true that this form of treatment is important in the management of the disease

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CHRONIC ULCERATIVE COLITIS COMPLICATED BY CARCINOMA OF THE COLON AND RECTUM

RICHARD B. CATTELL AND EARL J. BOEHME

INCREASING attention must be focused on carcinoma as a complication of ulcerative colitis. Ulcerative colitis predisposes to malignant disease of the colon by the very nature of the repeated infections followed by attempts at healing with the production of polyps, pseudo polyps, scar tissue, and often malignant growth. In the past seven years we have operated on 9 patients with ulcerative colitis and associated malignancy in the colon or rectum. As a rule, these are highly malignant tumors and unless surgical intervention is early, the outlook is poor.

A detailed study of the histories of these cases to be published elsewhere showed the ulcerative colitis to have an average duration of more than nine years before a change of symptoms or the accidental finding of carcinoma at the time of colectomy. Thus, ulcerative colitis, whether in remission or in the active stage, requires the same vigilance. We have found carcinoma in one case in which the disease had been present without remission for only three months and in another for three years. In the majority, however, the disease is present with remissions and relapses for many years. The absence of symptoms or an apparent cure after many or even a few years of ulcerative colitis is no insurance against the development of malignancy.

Two cases, presented here in detail, are illustrative of the varied aspects of this complication.

CASE I—This 27 year old man came to the Clinic in April 1940, with a thirteen year history of attacks of bloody diarrhea. He had many periods of remission followed by diarrhea of mucus, pus and blood. His last relapse began a year before admission and had been of constant severity. He had lost 15 pounds in weight and had eight loose stools daily.

His general physical condition was within normal limits except for evidence of weight loss. All of the laboratory studies were within normal limits. Examinations of the stool for ova, parasites and *Endamoeba histolytica* were negative. A proctoscope was introduced with difficulty and showed a scarred and contracted rectum. On roentgenologic examination a severe chronic ulcerative colitis was demonstrated. The bowel was rigid and tube like with marked haustra

total colectomy. Convalescence was uneventful and he left the hospital on the seventeenth postoperative day. It is interesting to note that during the next three months an alopecia totalis developed which was thought to be caused by avitaminosis. He recovered a normal hair growth later and his general condition improved. Three months after his ileostomy he was readmitted

to the hospital for second stage colectomy. At that operation the terminal ileum, ascending, transverse and part of the descending colon were removed and on section showed typical advanced chronic ulcerative colitis.

The final admission was two months later at which time the remaining descending colon and rectum were removed. On microscopic examination the specimen showed a typical adenocarcinoma with foci of carcinoma simplex associated with chronic ulcerative colitis.

The patient has been examined yearly since his total colectomy and shows no evidence of recurrence over five years after operation. He maintains excellent health and reports that he is able to play tennis. He wears a Rutzen bag with complete control of the ileal discharge.

Comment—In this case the total colectomy removed the carcinoma which was unsuspected at the time of operation. It is fortunate that the indication for total colectomy coincided with the early stage of the malignancy. This patient had a thirteen year history of relapsing ulcerative colitis which finally became intractable and required total removal of the colon. Certainly if repeated infection and irritation with attempts at healing are factors in the development of carcinoma this case can be added as evidence to support the hypothesis.

CASE II—This 53 year old man was first seen at the Clinic in May 1942. His history of ulcerative colitis began in 1924 with diarrhea of blood, pus and mucus. For many years he had relapses which were treated with paregoric, heat, bed rest, atropine, vitamins, diet, vaccines and silver nitrate enemas. In 1940 and 1941 the diagnosis of ulcerative colitis was made by roentgenologic examination and an operation for rectal stricture was advised but refused by the patient. Following this he enjoyed some remission of the disease until eighteen months before admission. Since that time he had bloody diarrhea of five to twenty movements in twenty-four hours. He lost 51 pounds in weight and was becoming progressively weaker.

Physical examination revealed a well developed large white male who showed evidence of recent weight loss. The liver margin was easily palpable three finger breadths below the right costal margin. Rectal stricture prevented the introduction of the proctoscope. Barium enema roentgenography showed the entire colon to be tubular, markedly contracted and rigid. There were no normal markings. There was exaggerated emptying with marked mucosal changes throughout. The concentration of hemoglobin was 7.8 gm per 100 cc of blood. Erythrocytes numbered 4,300,000 and leukocytes 10,750 per cubic millimeter of blood. Blood smear exhibited marked achromia of the red cells. The urinalysis revealed a 2+ albumin with occasional granular casts. On admission to the hospital the nonprotein nitrogen was 22 mg per 100 cc of blood, the hematocrit was 28 per cent and the chlorides were 495 mg per 100 cc of whole blood. In view of the chronicity and intractability of the disease, colectomy was advised and accepted by the patient.

After preparation with whole blood transfusions and administration of glucose and saline solution the patient was operated upon and a divided loop ileostomy was done. At operation a fixed mass was found at the hepatic flexure. A biopsy specimen was obtained but no further exploration was done. Microscopic examination of the specimen revealed a mucinous carcinoma. The patient did well and was discharged on his nineteenth postoperative day.

In June 1942, six weeks after ileostomy the patient was readmitted to the hospital. He had gained weight and strength so rapidly since his ileostomy that he wished to be operated upon with the possibility of resection of the lesion. At

reoperation the mass was found to be fixed and there were implants of mucinous carcinoma in the general peritoneal cavity. This patient died at home in December 1942 seven months after his initial operation.

Comment—This patient had a history of an eighteen months' warning that something more serious than a relapse of his colitis was occurring. The fact that roentgenologic study did not reveal the lesion after it had existed for this length of time serves to place the onus of decision on the clinical history and condition of the patient. Loss of weight and increase in bloody stools in an already seriously damaged colon definitely indicate the necessity of doing a total colectomy with removal of any concomitant malignant lesion.

SUMMARY

There is a significant incidence of carcinoma complicating chronic ulcerative colitis. Although the average duration of the disease before the development of malignant disease is more than nine years, it may develop at any time. Careful follow up study of all ulcerative colitis patients is necessary regardless of how long the ulcerative colitis has been in remission. Earlier surgical intervention when warning symptoms appear will materially improve the prognosis when carcinoma is present. Broadening the indications for colectomy will remove unsuspected carcinomas in some patients and prevent the subsequent development of malignancy in others.

CONGENITAL MEGACOLON

RICHARD B. CATTELL AND BENTLEY P. COLCOCK

VARYING degrees of dilatation of the colon as a result of obstruction or of disordered function are seen frequently. True congenital megacolon or Hirschsprung's disease, on the other hand, is uncommon, but its management is a serious problem. Dilatation is usually greater than is seen with the acquired type and commonly involves the sigmoid, sigmoid and rectum and occasionally the entire colon.

The etiology of congenital megacolon is obscure. It has been suggested in view of the temporary benefit derived from sympathectomy that a congenital imbalance of the autonomic nervous system is responsible for the initial pathology.¹ It may be that the pathology originates in the intrinsic innervation of the bowel wall, that is in the plexus of Auerbach, and not in the extrinsic sympathetic nervous system (Jordan and Swarts).

The symptoms in this group begin shortly after birth, but by the time treatment is undertaken, secondary pathologic change, namely fibrosis of all coats of the bowel wall, particularly the muscularis, has altered profoundly the fundamental problem. We are no longer dealing with an atonic but otherwise normal bowel wall but an hypertrophied bowel wall which may no longer be altered by sympathectomy.

The entire group of 27 patients with megacolon will be reported in detail elsewhere.² We will discuss briefly only that small group of 6 patients who were submitted to surgical treatment and who represent examples of true congenital megacolon. These were observed in a six year period from 1939 to 1945.

The ages of these patients were 17, 16, 13, 10, 17 and 8 years in the order they are reported. Each gave a history of obstinate constipation present since birth in spite of laxatives and enemas, all had chronic abdominal distention. At times this distention would become very marked and be associated with severe abdominal pain, followed by nausea and vomiting. Marked interference with nutrition was evidenced by their emaciated, anemic appearance on physical examination.

Patients with milder degrees of megacolon may be carried along satisfactorily on medical management, but one must always be on guard lest obstructive episodes lead to perforation and death. Grimson, Vandegrift and Dratz found in the literature a mortality from medical treatment ranging from 19 to 79 per cent, with an average of 58 per cent, for the more severe forms of megacolon, particularly in that

group of patients in whom the rectum is not much involved (Cases I, II, III, V and VI)

In those patients with associated dilatation of the rectum, operation can eliminate most of the dilated colon, with a decrease in the size of the abdomen and a reduction in the likelihood of perforation, but they must still be watched for the development of fecal impaction (Case IV)

In attempting to promote the easier evacuation of the rectum in this patient a rectal dilatation and pectenotomy were performed, with no improvement. This is in agreement with Dixon's experience that rectal dilatations are of little value in the treatment of true congenital megacolon.

Sympathectomy has long been recommended for the treatment of congenital megacolon⁴ and recently Penick has reported his experiences with it. We were encouraged with the immediate results of bilateral lumbar sympathectomy in 2 patients (Cases I and II). However, both of these patients had recurrence of their symptoms within a year. The first patient showed good clinical improvement and the barium enema was essentially normal two months later. There was no appreciable change in the size of the colon in spite of the temporary clinical improvement in the second patient.

It is our opinion that subtotal colectomy is the treatment of choice for advanced cases of congenital megacolon. Because of the possibility that an imbalanced autonomic nervous system may be the primary pathologic condition and because segmental resection of localized megacolon has been followed by recurrent symptoms and dilatation of the remaining colon (Grimson) a sympathectomy was performed along with the Mikulicz resection of the left colon in Cases IV and VI. In patients in whom the proximal colon is involved as well we have preferred to remove the entire colon around to the rectosigmoid forming a double barreled Mikulicz spur with the terminal ileum and the uninvolved rectosigmoid (Cases III and V). We prefer the Mikulicz type of anastomosis as a two stage operation rather than primary resection because of the changes in the wall of the distal segment which makes primary suture hazardous. An opinion in agreement with Whitehouse, Bergen and Dixon.

REPORT OF CASES

CASE I—A 17 year old white female was first seen at the Clinic on January 9 1939 because of marked constipation and a dilated colon. The patient stated that she had always been constipated and had required laxatives in order to have bowel movements. These movements occurred every second or third day occasionally once a week and each required a good deal of straining. A barium enema performed a year previously showed a large dilated colon. In addition to abdominal discomfort and pain she complained of fatigue and headaches. At this time she required a 2 quart enema to have a bowel movement.

Abdominal examination revealed a full, palpable colon. Roentgenologic examination demonstrated a megacolon, largely localized to the sigmoid. She was placed on medical management.

In August 1939 her bowel action was improved, and she had gained weight. At this time a barium enema revealed the entire colon to be larger than normal with the greatest enlargement in the sigmoidal loop. A barium enema on August 20, 1940, a year later, demonstrated marked dilatation of the colon and there was poor emptying. Both the patient and her mother felt that her condition was becoming worse. She was admitted to the hospital for bilateral lumbar sympathectomy, which was carried out on August 23, 1940. At operation, the dilatation was found to be most marked in the descending colon and sigmoid. The bowel was mobilized and the left lumbar sympathetic trunk including the second, third and fourth ganglia, was removed. The right colon was then mobilized and a similar excision of the right sympathetic trunk was carried out. The peritoneum was reapproximated. The appendix was removed. Convalescence was uneventful and she was discharged on medical management of her megacolon.

In September 1940 she looked and felt well and was having three spontaneous bowel movements a week. In October 1940 her condition was good. Barium enema showed no dilatation of her bowel and there were good haustral markings. In June 1942 she was again having irregularity in her bowel movements. With the aid of mineral oil and enemas she had a bowel movement every two or three days and was avoiding distention and colon accumulation.

CASE II—A 16 year old boy first came to the Clinic on April 15, 1940, complaining of constipation present throughout life. He was first seen by the family physician for this condition at the age of 2 at which time a large fecal impaction was found. A roentgenogram of the colon at that time showed marked dilatation producing the distention of the abdomen. He got along fairly well under medical treatment until the age of 3 when mineral oil and enemas failed to work satisfactorily. Since that time he has had to be taken to the hospital on numerous occasions and given an anesthetic for the removal of a rectal impaction. At the time of our examination he was having increasing abdominal pain.

On physical examination, a hard mass was felt filling the left side of the abdomen, extending from the pubis to the costal margin. On rectal examination a large impaction was found just inside the sphincter continuous with the abdominal mass. The remainder of the physical examination was negative.

The patient was admitted to the hospital where under cyclopropane anesthesia a tremendous fecal impaction was removed. This was felt to be a good case for sympathectomy and it was advised. It was carried out on August 5, 1940 with removal of the second, third and fourth lumbar sympathetic ganglia on each side. At this time the distal colon was found to be markedly atonic and dilated. The proximal colon (right and transverse) was moderately dilated, with good tone throughout the bowel wall.

Convalescence was uneventful and a barium enema on August 25 revealed haustral markings even though the distal time of his discharge he was able to make

daily bowel movement, but these were small. Large, sausage shaped masses could be felt on abdominal examination. Barium enema revealed a large dilatation of the sigmoid with normal proximal colon. In March 1941 he reported having considerable difficulty with his bowel movements and later developed repeated impactions in his rectum. He was advised at this time to have excision of his dilated colon. In February 1946 the patient was working but still required hospitalization three to four times a year for removal of fecal impactions under spinal anesthesia. His physician reports that

impactions have been removed on the following dates February 2 and September 17, 1942, April 14 and September 28, 1943, January 29, June 19, October 6 and December 18, 1944, May 5 and August 13, 1945, and January 7, 1946. He further states that the patient 'has no evacuations except at these times'

CASE III—A white boy of 13 was first seen at the Clinic February 9, 1943, because of severe constipation and distention of the abdomen present since birth. Abdominal distention often increased to the point where it led to vomiting. For the last two years a daily enema had been necessary and four weeks previously the vomiting, distention and constipation had been so severe that the patient had had to stop school, have bidaily enemas and was able to eat only small amounts of food.

Physical examination revealed that the patient was emaciated, with a markedly distended abdomen and accentuated peristaltic sounds. A roentgenogram after a barium enema demonstrated a tremendous dilatation of the colon, particularly of the sigmoid (Fig 286). He was admitted to the hospital on February 9, 1943,



Fig 286 (Case III)—Dilated sigmoidal loop filled with barium coated feces

and placed on a medical regimen including mechiolyl bromide. He improved, the size of his abdomen decreased and he began to have a daily movement and to gain weight. He was discharged on February 24, 1943, to continue with mechiolyl and mineral oil three times daily.

The patient was well for a few months but in June 1943 began to have intermittent bouts of partial obstruction associated with vomiting. He was admitted to the hospital and when the obstruction failed to respond to intubation of the small bowel, an emergency sigmoidostomy was carried out on August 23, 1943. Progress postoperatively was slow but steady, and the abdomen gradually was decompressed. He was discharged much improved on September 14, 1943. On November 2, 1943, he was feeling well. There was still some drainage from the sigmoidostomy wound. Although he looked and felt well the colon was gradually filling up and he was advised to enter the hospital. At operation, February 5, 1944, the hypertrophy and dilatation were found to stop abruptly at the lower sigmoid. Subtotal colectomy was performed (Fig 287), with formation of a

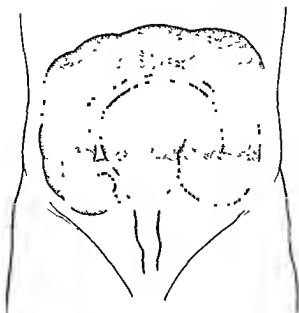


Fig 287 (Case III) —Diagrammatic representation of the extent of the dilated colon The shaded area was resected

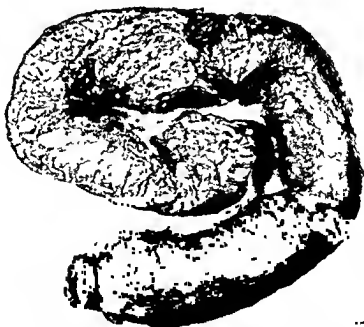


Fig 288 (Case III) —The ascending, transverse and descending colon removed at operation

double barreled Mikulicz ileosigmoidostomy. The pathologic examination showed marked hypertrophy of the musculans (Fig 288).

Convalescence was satisfactory and the patient was discharged March 6, 1944. On April 28, 1944, the colostomy was closed. He was feeling well and much improved. He was seen again December 14, 1944, at which time he had gained 30 pounds in weight, his bowels were moving two or three times daily and his general condition was excellent.

CASE IV—A young white girl, 10 years of age, was first seen August 3, 1942, complaining of bowel trouble present since the age of 4. Since that time she had had periods of constipation alternating with periods of diarrhea, usually associated with severe cramps. At times these cramps were severe enough to lead to a state of collapse.



Fig 289 (Case IV)—After evacuation of barium enema, August 24, 1942. Dilatation extends from splenic flexure to anal canal.

Physical examination revealed a thin, undernourished child, having considerable abdominal pain. The abdomen was markedly distended, with many palpable solid masses following the outline of the colon. A large fecal impaction was present in the rectum. She was admitted to the hospital August 4, 1942, and the impaction broken up under anesthesia and removed. She was discharged August 11, 1942, under medical treatment for megacolon, including mecholyl bromide, 0.1 gm twice daily. A roentgenogram after a barium enema was made on August 24, 1942, and demonstrated a tremendous dilatation of the rectum and rectosigmoid, which filled the entire left half of the abdomen (Fig 289).

The patient was seen September 21, 1942, at which time her bowels were moving only with the aid of enemas twice a week. The dose of mecholyl was increased from 0.1 gm to 0.2 gm twice a day. She improved somewhat during the next few months. She was seen again in April 1943, having reverted to her



Fig 290 (Case IV) After full barium enema May 26 1944 Marked dilatation of the entire colon extending to the anal canal

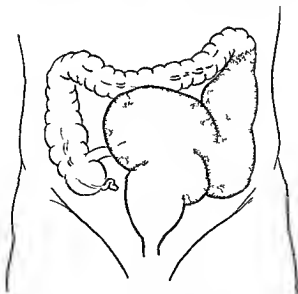


Fig 291 (Case IV) —Diagrammatic representation of the extent of the dilated colon Note that it includes the rectum The shaded area was resected

previous condition. She had vomited once three weeks previous to her visit. She improved somewhat during the next few months again, but when seen in October her abdomen was still markedly distended and tender. In May 1944 this had increased to a point where she was advised to enter the hospital again.

The patient was admitted to the hospital on May 16, 1944, and a pectenotomy was performed for a spastic anal sphincter, followed by evacuation of the rectum and rectosigmoid. A barium enema May 26, 1944, revealed dilatation of the entire colon, which was particularly marked in the rectum and rectosigmoid (Fig 290). The abdomen continued to be distended and on September 21, 1944, she was admitted for surgical treatment. This was carried out on September 27, 1944, at which time a bilateral lumbar sympathectomy was performed in addition to a

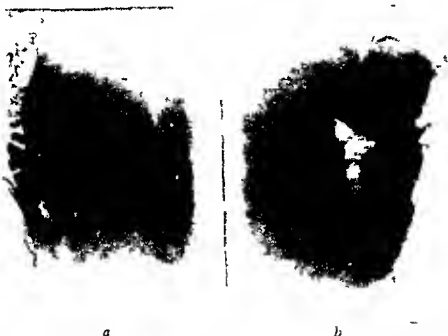


Fig 292 (Case V) —*a*, After a full barium enema. It was impossible to outline the loop.

b, After evacuation showing a large dilated sigmoidal loop and some dilatation of the left transverse and descending colon.

Mikulicz resection of the distal transverse colon, descending and upper sigmoid colon (Fig 291). The postoperative course was uneventful. The colostomy was closed on December 27, 1944.

The patient improved considerably after operation but continued to develop impacted feces in the dilated rectal stump and in March 1945 she required admission for evacuation of a large impaction under anesthesia.

CASE V—A 17-year old white girl was admitted to the Clinic on April 11, 1945, complaining of abdominal pain, loss of weight and weakness. She had suffered from constipation since childhood, associated with severe cramping abdominal pains centering in the right lower quadrant, most marked during the past year. She had had an appendectomy performed and the appendix was said to be normal. The pains recurred in one month and occasionally were associated with nausea and vomiting. She had had some edema of the ankles for the past two months.

Physical examination revealed that the patient was thin and anemic. There was a tender mass in the right lower quadrant and an elongated tender mass in the left lower quadrant. Rectal examination was negative. Roentgenogram of the chest was negative except for elevation of the left diaphragm by distention of the colon beneath. The red blood cell count was 3,100,000. A roentgenogram after a barium enema demonstrated an enormous dilatation of the sigmoid and moderate dilatation of the remainder of the colon (Fig. 292 *a* and *b*). The rectum and lower sigmoid were normal.

Operation was advised and was carried out May 7, 1945, under spinal anesthesia. The sigmoid, descending and transverse colon were found to be enormously dilated with moderate dilatation of the cecum and ascending colon. The remainder of the abdominal viscera was negative. The terminal ileum, ascending, transverse and descending colon were mobilized and resected (Fig. 293) with

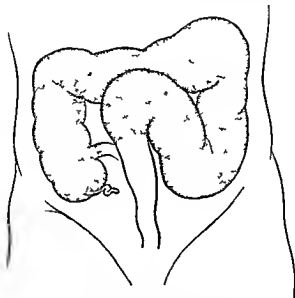


Fig. 293 (Case V) —The shaded area shows the extent of the dilatation and amount of colon resected.

formation of a double barreled Mikulicz spur of the terminal ileum and lower sigmoid colon. The denuded area was peritonealized and a catheter placed in the terminal ileum for immediate decompression.

Convalescence was uneventful. The patient was discharged June 3, 1945. She was readmitted on July 9, 1945, and a crushing clamp was placed on the remainder of the spur which had not been obliterated. She experienced discomfort which persisted for several days and was accompanied by fever. This subsided after sulfadiazine therapy and her general condition seemed excellent. An extraperitoneal closure of the colostomy was carried out July 23, 1945. On the first postoperative day the temperature rose to 104, fell slightly and then went to 105 and continued high. The patient appeared markedly toxic and there was increasing rigidity of the abdominal wall. Her course continued downhill and she died on the fifth postoperative day. Necropsy was performed and revealed generalized peritonitis with localized abscess in the left gutter.



Fig. 294 (Case VI).—*a*, Barium enema; marked dilatation of the sigmoidal loop is shown. The rectum was not greatly dilated. The right colon was only partially filled but not increased in size.

b, After evacuation; gas filled sigmoid and descending colon are evident. The rectum shows contractability.

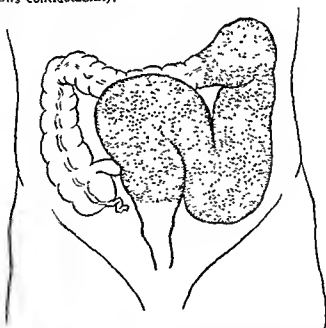


Fig. 295 (Case VI).—The shaded area shows diffuse dilatation of the left colon; the rectosigmoid was relatively free.

CASE VI—A white boy, 8 years of age, was first seen at the Clinic on September 17, 1945, complaining of severe constipation present since birth. The

constipation had been particularly marked during the preceding six weeks, enemas were no longer effectual and he usually required manual help in having an evacuation. His abdomen was always distended, sometimes markedly so, particularly in the epigastrium.

Physical examination revealed an undernourished, underweight young male with a markedly distended abdomen. Digital examination demonstrated a large fecal impaction which required manual removal. Following removal of the impaction a barium enema was given and revealed a markedly dilated colon, most marked in the sigmoid colon (Fig 294, a and b). He was admitted to the hospital September 19, 1945.

At operation, the colon was found to be greatly distended beginning at the splenic flexure and extending down to the rectum (Fig 295). A Mikulicz resection of the sigmoid and descending colon was carried out in addition to a left lumbar sympathectomy on September 22, 1945. The postoperative course was uneventful and he was discharged on October 9, 1945 in good condition.

The patient was seen November 23, 1945, at which time his condition was excellent. He was having daily movements through his colostomy and there was no abdominal distention. His colostomy will continue to function for six months in order to permit shrinkage of the distal bowel (rectum), following which the spur will be divided and the colostomy closed extraperitoneally.

COMMENT

Lumbar sympathectomy for congenital megacolon, carried out in two cases which have been observed over a period of six years after operation, has not given satisfactory results. The first patient was relieved temporarily and her colon returned to normal size, with normal haustral markings. Subsequently, symptoms recurred in spite of continued medical regimen, and enemas were required for satisfactory evacuation. She could be considered as improved but not relieved.

The second patient had immediate improvement in his symptoms without appreciable change in the caliber of the colon. He requires occasional mechanical removal of large fecal impactions, and must be considered an unsatisfactory result.

It is our opinion that lumbar sympathectomy alone offers little chance of complete relief of congenital megacolon. If it is to be used as the only surgical procedure combined with medical treatment, it should be reserved for those cases with diffuse enlargement of the colon of moderate degree, and which are not relieved by medical treatment alone. We think it will be applicable to but few cases.

Congenital megacolon is best treated by segmental or subtotal colectomy. The best results can be anticipated when the dilatation does not involve the rectosigmoid and rectum. In Cases IV and VI, the dilatation was confined to the left colon, permitting segmental resections. In Case VI, the marked dilatation stops at the lower sigmoid, and it was possible to join normal transverse colon to normal rectosigmoid. In Case IV, the entire left colon, including the rectum, showed the same degree of dilatation. As a result, a dilated lower segment was left and the patient continues to have symptoms. No procedure short

of hemicolectomy and abdominoperineal resection with permanent colostomy of the transverse colon would assure relief in this patient. Such a radical procedure does not seem justified for this benign condition. The danger of volvulus and the danger of perforation of the short distal loop, part of which is extraperitoneal, have been greatly minimized.

In both cases, resection was accompanied by bilateral lumbar sympathectomy. Mobilization of the transverse colon permitted reestablishment of continuity by means of Mikulicz anastomosis. This safe procedure is recommended since it avoids primary intraperitoneal suture of intestine which may be involved. It is possible that resection alone will be sufficient to relieve these patients, but we recommend that the combined procedure be utilized.

Subtotal colectomy will be required for patients having dilatation involving the entire colon and is the preferred procedure. In these cases (III and V) restoration of intestinal continuity can be obtained by joining the ileum to the rectosigmoid by the Mikulicz procedure. Case III had an excellent result, yet it will be noted that he was having two or three movements per day. Case V should have been equally satisfactory but unfortunately was an operative fatality. Subtotal colectomy, joining the ileum to the rectosigmoid stump, offers the greatest chance of complete relief in these extensive cases. Since the fecal discharge is liquid or semiliquid, fecal impaction does not occur. Lumbar sympathectomy is not necessary with subtotal colectomy, and was not done in either of these cases.

SUMMARY

Congenital megacolon is rare. Six patients have been operated upon at the Lahey Clinic from 1940 to 1945 inclusive, and are reported. The operation of choice is segmental or subtotal colectomy. Lumbar sympathectomy as the only operative procedure offers little chance of permanent relief and if employed should be reserved for the milder cases with diffuse dilatation. Medical treatment should suffice for these cases without operative intervention. Lumbar sympathectomy may be combined with segmental resection but should not accompany subtotal colectomy.

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SURGICAL TREATMENT OF INTESTINAL TUBERCULOSIS

RALPH ADAMS AND WALTON H. MILLER

MORE than 100 cases of intestinal tuberculosis have been seen at the Clinic in the fifteen year period prior to 1946. In a majority of these cases the clinical diagnosis has been supported by roentgenologic findings compatible with that lesion. Many of these patients also had pulmonary tuberculosis, were referred to sanatoria, and their subsequent course is unknown to us. Records were available, however, on 19 patients who received surgical treatment, and from those cases we have tried to arrive at some conclusions concerning the usefulness of such intervention.

There is little question that the greatest incidence of intestinal tuberculosis is found in the cecum, ileum and colon, named in the order of frequency of occurrence. Rokitsky, in his work on pathology of tuberculosis (1845), emphasized that the first tubercles investing the intestinal tract are found in lymphoid tissue, and that this tissue, being abundant in the region of the cecum and terminal ileum, probably represents one argument for its predilection. It is also suggested that considerable stasis is present in this region and that contact with the tuberculous bacillus may be more sustained. Cullen believes that a portion of the alimentary spread may be hematogenous dissemination from a tuberculous infection elsewhere in the body.

In this group of cases the youngest patient was 16 and the eldest 66 years of age, the average age was 39 years. This is somewhat higher than the average age group reported in larger series. Eyerly and Breuhau reported 30 as being the predominant average age. There were 18 females and 6 males. The duration of the disease varied from three weeks to twelve years, the average duration being three years.

SYMPTOMATOLOGY

The most common complaint in the group of individuals examined was abdominal pain. This was present in three fourths of the cases. It was usually intermittent in character, colicky in nature, and was quite often localized to the right lower quadrant and periumbilical region. Four of the patients had diarrhea, 3 increasing constipation and in the remainder there was no change in the bowel habit. Only 1 patient had melena. The second most common symptom was weight loss. Fifty per cent of the patients had this symptom. Vomiting occurred in 3 cases, and there were draining abdominal sinuses in 4 cases. It has previously been thought that intestinal tuberculosis was

rare unless there was a preexisting pulmonary lesion. In this series of cases there were 5 patients whose roentgenograms showed pulmonary tuberculosis, 6 that did not, and in 8 cases roentgenograms were not taken of the chest but clinical examination was negative. In general, the symptomatology was similar to that previously reported.¹

AIDS TO DIAGNOSIS

It is recognized that in most patients who die from tuberculosis of the lungs ulceration in the bowel will be found at autopsy. Burke and Aronovitch, in a series of 90 necropsies on tuberculous patients, found ulceration of the bowel to be present in 70 cases. As seen in this series of surgically treated cases, however, 6 patients had tuberculosis of the bowel without pulmonary findings. If a patient is under treatment for pulmonary tuberculosis, and the lesion seems to be progressing favorably and yet the patient has fever, malaise and weight loss, intestinal tuberculosis certainly should be seriously considered.

The most helpful diagnostic aid which we have found is the barium enema. We believe, however, that the diagnosis is best made by using both the barium enema and the barium motor meal. The study should include fluoroscopic examination in all instances. The roentgenologic signs of tuberculosis in the ileum are segmentation and dilatation of the ileal loops, although such findings may also be present in regional ileitis and after subsidence of a nonspecific peritonitis.

The signs in the cecum, as stated by Hare, are an ulcer crater, persistent irregularity of the cecum, continued spasm of the ileocecal valve, persistent mottling at the time of reexamination, loss of central markings, a funnel shaped cecum with annular swelling of wall at the valvula, and narrowing, relative rigidity and long, shriveling of the cecum and ascending colon.

The differential diagnosis between a case of tuberculous and one of regional ileitis is roentgenologically difficult. The "stricture" so aptly described by Kantor, is of definite value but differential diagnosis is often impossible.

Carcinoma of the cecum also presents many perplexities in roentgenologic diagnosis and sometimes cannot be distinguished from tuberculosis. If the terminal ileum is involved, presumptive evidence that the lesion is tuberculous. Ulcerative colitis may also be confused with a tuberculous lesion. A worthwhile aid is that the former disease involves cecum and rectum. If it occurs in the segmental localization, diagnosis frequently cannot be made.

SURGICAL TREATMENT

The following observations are based upon 11 surgically treated cases.

1 Tuberculous Fecal Fistula—Four patients had tuberculous lesions in the sigmoid with abdominal wall fistulas in which closure was attempted by enfolding the bowel perforation with two layers of inverting sutures

In the first case primary closure of multiple sigmoidal fistulas was done without diversion of the fecal stream. The fistulas recurred and when it became necessary to do a colostomy tuberculosis was found to be present in the transverse colon. At the conclusion of a series of operations over a six year period a fecal fistula was still present and the tuberculous process had extended to involve the entire colon. This case is illustrative of the fact that tuberculous fistulas from the bowel can rarely be closed in the presence of active infection and without proximal diversion of the fecal stream.

In the second case two fistulas were closed and a proximal Mikulicz type colostomy done. Healing occurred and there was systemic improvement. The colostomy was closed six months later but failed to heal. New fistulas developed and there was extension of intestinal tuberculosis. A second colostomy was done but the sinuses failed to heal and three and one half years after the initial operation the patient continued to have draining abdominal sinuses and her entire colon appeared to be involved. If one is successful in obtaining closure of a tuberculous fistula after a proximal colostomy the diversion of the fecal stream should probably be maintained for at least a year and preferably for two years after apparent healing lest the sinuses reopen or new ones form at the site of colostomy closure.

In the third case a persistent draining sinus following an appendectomy was but one indication of active tuberculosis involving the sigmoid fallopian tubes ovaries and colon. There was clinical improvement after resection of a tubo ovarian abscess closure of a sigmoidal fistula and establishment of an ileostomy. Three months later the ileostomy was closed. Drainage persisted from the laparotomy scar and eight years after the initial examination evidence of tuberculous colitis still was present. We believe that this case demonstrates both adequate and inadequate therapy. The removal of the infected pelvic mass into which fecal material was draining and diversion of the fecal stream by an ileostomy were essential steps in saving the patient's life and her unfavorable course was changed to one of clinical improvement. Closure of the ileostomy after three months however disregarded the principle of prolonged rest for the involved organ which in reality provides the most effective therapy known for an active tuberculous infection wherever situated in the body. One or two years of sanatorium type care before closure of the ileostomy might have increased the likelihood of arresting the tuberculous colitis.

In the fourth case a localized tuberculous enteritis of the sigmoid

had perforated into a tubo ovarian mass. The sigmoidal fistula was closed. The pelvic mass, which included the uterus, tubes and ovaries, was resected, and a Mikulicz type colostomy was formed in the transverse colon. The colostomy was closed ten months later and the patient has been well for three years. It should be noted, however, that the sigmoidal lesion was an isolated one in respect to the colon, that the secondarily infected pelvic mass was removed, and that almost a year of rest was allowed the sigmoid before the colostomy was closed. It is this type of case, approximately so managed, in which one may expect the best results following closure of a tuberculous fecal fistula.

2 Tuberculosis of Ileum and Right Half of Colon.—Seven patients had tuberculous lesions of variable type with involvement of the terminal ileum, cecum, ascending colon or hepatic flexure. In these, a resection of the terminal ileum and right half of the colon was done with the formation of an ileotransverse colostomy, according to the Mikulicz plan. By this technic the ileum and transverse colon are brought out together through the abdominal wall as a double barreled colostomy, and a long intra abdominal approximation is secured by suturing the ileum to the transverse colon with two layers of interrupted sutures. At a later date, usually six to eight weeks, a secondary extraperitoneal closure of the colostomy is done after the intervening spur has been divided.

In the first case, a woman of 53 years, tuberculous enteritis limited to the terminal ileum and ascending colon was resected. The operation was done with the knowledge of coexisting minimal but active tuberculosis of the lung, because a diagnosis of carcinoma of the right colon could not be excluded. The abdominal tuberculosis was apparently eliminated and there was no further trouble after closure of the colostomy two months after the resection. Progression of the pulmonary lesion, however, required admission to a sanatorium for treatment. As a matter of principle, operation for intestinal tuberculosis should not be undertaken when there is an active pulmonary infection except when mandatory because of obstruction, internal perforation or likelihood of carcinoma.

In the second case, a woman of 60 years, a resection was unquestionably indicated because of partial chronic obstruction from an inflammatory mass involving the terminal ileum, cecum and ascending colon, with stricture formation at the hepatic flexure. Here again, carcinoma could not be excluded prior to pathologic examination of the specimen. The pathologic change demonstrated was that commonly encountered in a hyperplastic, stenosing, tuberculous lesion, namely, destruction and distortion of the submucosa and muscularis by a chronic inflammatory process of low grade and accompanied by much thickening. Two months later the ileocolostomy was closed.

Follow up examination of this patient one year later showed her to be in good condition

In a third case, a man of 22 years, with bilateral pulmonary tuberculosis and multiple external tuberculous sinus tracts from the right colon and ileum, the pulmonary lesions had been controlled by sanatorium care, artificial pneumothorax and thoracoplasty. Right colectomy and closure of the colostomy were followed by uncomplicated healing. The patient has not been followed since hospital discharge but, except for the incomplete follow up, the case is believed to demonstrate a more nearly correct management of the combination of pulmonary and intestinal tuberculosis than has been accomplished in some of the other cases.

In a fourth case a woman of 57 years, with partial obstruction from a tuberculous hyperplastic stenosing lesion in the ileocecal valve, cecum and ascending colon, carcinoma was the preoperative diagnosis. Tuberculosis was also considered because of the marked fore shortening in the cecum, demonstrated by a barium enema. The colostomy was closed three weeks after the resection. There were no complications and at the time of the last follow up examination, nine months after colostomy closure, the patient was apparently well.

In a fifth case, a man of 60 years, the findings and treatment were almost identical to those in the fourth case. The patient has been followed for three and a half years, without evidence of recurrence.

The second, fourth and fifth cases illustrate the good results that may be anticipated following surgical procedures of this type in patients beyond 50 years of age with localized, hyperplastic, stenosing tuberculosis of the right colon. In such cases one is removing a mechanical obstruction rather than controlling a tuberculous infection by doing a resection. The infection had already been controlled by natural processes of healing and resistance. The procedure might equally well have been done by an internal ileocolostomy and resection had that been the technic preferred by the operating surgeons.

In a sixth case, a woman of 33 years, there was fibrotic tuberculous involvement of the right colon, cecum and ileocecal valve. The terminal $2\frac{1}{2}$ feet of the ileum was dilated, with hyperemia of the wall, edema of the small intestinal mesentery and enlargement of the mesenteric lymph nodes. A resection including 3 feet of the terminal ileum and all of the right colon around to the middle colic artery was done and two months later the colostomy was closed. No sinuses developed. She did not have pulmonary tuberculosis but within a year there was recurrence of blood and diarrhea. Roentgenologic examination showed changes consistent with ulcerative colitis in the remaining ileum, the anastomosis and in the colon. This case adds emphasis to a point made in the discussion of the cases of tuberculous fistula that direct surgical attack upon an active tuberculous process

is rarely successful. One errs in judgment in attempting to resect exudative tuberculous lesions. Only disappointment and recurrence should be expected if function is restored through an anastomosis made in tissues involved in this phase of tuberculosis. Two alternatives are suggested. The first is sanatorium treatment until the infection is quiescent when there is not a contraindicatory situation. The contraindications to postponement of operation are, as previously mentioned, obstruction, internal perforation and inability reasonably to distinguish the lesion from carcinoma. The second alternative is resection but maintenance of a colostomy for a long period.

In a seventh case a woman of 49 years, an obstructing mass in the cecum accompanied by a marked inflammatory reaction in the mesentery of the cecum and ileum was found. Pathologic examination proved both adenocarcinoma and tuberculosis to be present. The colostomy was closed three months later. The wound healed and the anastomosis remained patent, but she died two and a half years later of carcinomatosis.

This case is included as proof that both tuberculosis and carcinoma can occur in the cecum simultaneously.

8 Tuberculous Lesions Treated by Primary Anastomosis—This type of operation was done in 7 cases.

In the first case, death occurred from peritonitis on the third postoperative day following resection of the terminal ileum ascending and proximal transverse colon and formation of an internal ileo-transverse colostomy.

In the second case a similar operation was done for what was thought to be a large carcinoma of the cecum and the correct diagnosis of tuberculosis was not established until the specimen was examined pathologically. The course during the very short follow up period since operation in December 1945 has been entirely satisfactory.

In a third case an attempt was made to relieve obstruction caused by multiple ileal and cecal strictures in a patient with tuberculous peritonitis by establishment of an ileotransverse colostomy. Death occurred on the twelfth postoperative day from ileus and diffuse bronchopneumonia. The surgical procedure performed was based more upon hope than expectation of benefit in a very sick patient with mechanical intestinal obstruction as only one of the multiple disease processes.

In a fourth case an ileocolostomy was done to bypass ulcerative obstructing tuberculous lesions in the ileum and cecum. The wound healed by primary union and the obstruction was relieved but death occurred from the disease a few months later. The palliative object for which the operation was done was accomplished.

In a fifth case a tumor mass in the jejunum was resected and a

side to side anastomosis done to relieve intermittent intussusception and obstruction. The proper diagnosis was not suspected until examination of the specimen revealed tuberculosis extending to the resected lymph nodes. The wound healed by primary union. The follow up extended through only one year but there was no evidence of recurrence during that period.

There are many who believe that a side tracking operation for this type of tuberculous lesion is preferable to resection but in this instance the diagnosis was thought to be that of tumor until the lesion was removed and sectioned.

In a sixth case obstruction was caused by one of six fibrotic annular lesions in the ileum which had healed under a regimen of sanatorium care. The obstructing lesion only was resected and a primary side to side anastomosis of the ileum was done. After an additional year in the sanatorium the patient was discharged in good health. This case represents the ideal type of care for intestinal tuberculosis namely strict sanatorium care surgery only for a specific indication such as mechanical obstruction and return to the sanatorium for further treatment.

In a seventh case the right half of the colon and all but 5 feet of the small intestine were resected for tuberculous ileitis and lymph nodes with numerous skip areas. At the time of operation the diagnosis was thought to be regional ileitis but tuberculosis was considered also because of an old inactive pulmonary lesion and because of numerous enlarged nodes in the intestinal mesentery. In July 1945 the jejunum was connected to the transverse colon by an end to end anastomosis. Convalescence was satisfactory and no fistula developed. It is only eight months since the operation but the patient has gained weight and is feeling well. The only symptom is that of four bowel movements daily.

4 Miscellaneous Cases—In one case a very painful infected mass caused by perforation of tuberculous diverticulitis into the sigmoid was resected and a colostomy established. The distal bowel end was dropped beneath the pelvic floor and the presacral space was drained through the perineum. The rectum was not removed because of marked cardiac enlargement and decompensation. The pain was relieved. Perineal drainage persisted two years later when the patient was last seen. The colostomy functioned well and the patient was grateful for the relief he had received.

In another case not treated surgically a tuberculous ulcer 4 by 3 cm. situated just within the anal sphincter was present when the patient was first examined in 1942. The diagnosis was proved by biopsy. Roentgenologic study of the chest and the upper and lower intestinal tract was negative for tuberculosis except for the isolated ulcer. Treatment consisted of a bland low residue diet vitamins and

est. In 1945, proctoscopic examination revealed the ulcer still to be present and active, but some diminution in size had occurred. The patient had regained her original weight and was having one bowel movement daily. No stricture had formed. The case is of interest because the ulcer could be observed visually and because it illustrates the chronicity of tuberculous ulceration in the functioning bowel. A proximal defunctioning colostomy would seem advisable in such a case.

SUMMARY

In a series of 19 surgically treated cases with a variety of intestinal tuberculous lesions, abdominal fistulas were closed in 4 cases, with recurrence in 3 and the closure was maintained for at least three and a half years in the fourth. Resection of the right colon with the formation of a Mikulicz ileotransverse colostomy and secondary closure was done in 7 cases. In 1, there was coexisting adenocarcinoma of the cecum. This patient died two and a half years later of carcinomatosis. Four patients apparently were well from nine months to three and a half years later. In 1 case the intestinal tuberculosis was eliminated but the pulmonary disease progressed. In 1 case there was recurrence and death four years following the initial operation. Resection of the right colon with primary ileocolic anastomosis was accomplished in 3 cases, with a postoperative death in 1 and a satisfactory result of three months and of eight months' duration in 2 cases at the time of writing this report. There were two resections of segments of small bowel with primary anastomosis, with recession of symptoms for one year. Two side-tracking ileotransverse colostomies were done, followed by a hospital death after twelve days in 1 and by death after nine months in the other. There was one resection of the sigmoid and a painful associated abscess, with the formation of a permanent colostomy. This patient has maintained a draining perineal sinus for two years, but has been relieved of pain.

CONCLUSIONS

1. Tuberculous fistulas can rarely be successfully closed in the presence of active intestinal tuberculosis. A diversionary colostomy should be maintained until the tuberculous process has been quiescent for at least a year.
2. Resection of the right colon affords greater prospect of cure in the hyperplastic, stenosing type of tuberculosis than in the active, ulcerative type.
3. In cases in which there is difficulty in ascertaining the extent of the lesion in tuberculosis of the right colon, an ileotransverse colostomy of the Mikulicz type, with secondary closure, would seem to be attended by less risk than a primary anastomosis.

4 Patients who have an active pulmonary lesion should have arrest of this lesion before abdominal operation for intestinal tuberculosis is undertaken. Exceptions to this statement are found in cases of acute obstruction, internal perforation and masses indistinguishable from carcinoma.

5 Intestinal tuberculosis may be present without demonstrable pulmonary disease.

6 The barium enema offers the greatest aid in the diagnosis of intestinal tuberculosis.

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INJURIES OF THE COLON AND RECTUM

BENTLEY P. COLCOCK

ALTHOUGH relatively infrequent in peace time, gunshot wounds of the colon do occur, just as the colon is occasionally injured in stab wounds of the abdomen. Not infrequently, the colon is lacerated in nonpenetrating injuries associated with automobile and other types of accident. Lacerations of the bowel may be multiple and extensive when vehicles collide at high speed even though the external evidence of violence is limited to ecchymosis of the abdominal wall or back. Regardless of the cause of the injury, an opening in the colon pouring fecal contents into the peritoneal cavity represents a very serious problem from the standpoint of mortality and morbidity.

Marked progress toward decreasing the morbidity and mortality associated with wounds of the colon was made during the recent war. It seems reasonable that some of the lessons learned may profitably be applied to the treatment of similar injuries encountered in peace time. Accordingly, an experience with 120 patients with perforating wounds of the colon or rectum admitted to a general hospital in the Mediterranean Theater of Operations will be briefly reviewed. This group of patients will be reported in detail elsewhere.

It is generally accepted that in patients with lacerating or perforating wounds of the abdominal wall, if exploration and debridement of the wound indicate that the peritoneal cavity has been entered, laparotomy and thorough examination of the abdominal viscera are imperative. In this connection it must be remembered that the peritoneal cavity may be entered, and peritoneal viscera injured, in patients with wounds of the chest, back, perineum or buttocks.

The diagnosis of intra abdominal injury may be particularly difficult in patients who present no external wounds, such as may occur in automobile accidents or in falls from a height. The violent impact upon the body which occurs in these accidents may lacerate the entire circumference of the small or large bowel, with minimal evidence of injury to the surface of the abdomen. On the other hand, extensive retroperitoneal hemorrhage occasionally associated with such accidents may result in fever, abdominal pain and rigidity of the abdominal wall closely simulating the picture of intra abdominal injury. The latter condition is, of course, treated conservatively, yet to treat these patients conservatively places considerable responsibility on the surgeon, for if lacerations of the small bowel and particularly of the colon are present, the result of conservative treatment is usually disastrous. He must also remember that because of the solid nature of

the colonic content, particularly on the left side, the physical findings in such cases may be entirely localized during the first few hours when the opportunity for successful operative treatment is greatest.

The decrease in mortality and in morbidity associated with wounds of the colon during the latter stages of World War II is due largely to three factors first, the use of blood in amounts which a few years ago would have been considered excessive. Not infrequently, 3000 to 4000 cc of blood was necessary to prepare these patients and carry them through their operative procedures. The second factor is the widespread use of sulfonamide compounds and penicillin both intra peritoneally and parenterally. Although many questions concerning the use and method of use of chemotherapeutic agents for perforating wounds of the abdominal viscera have yet to be answered, these drugs unquestionably have saved many patients who formerly would have died of peritonitis. Last but not least a large part of the credit is directly attributable to the skill and experience of the surgeons responsible for the primary surgical treatment of these patients.

Three fundamental principles must be kept in mind in the treatment of any wound of the colon. First, it must be handled in a manner that further leakage of intestinal content into the peritoneal cavity is prevented. Second, the treatment of the perforation must not result in any marked impairment of the bowel lumen. Third the operative procedure should add as little as possible to the shock that the patient has already experienced as a result of his injury.

For small wounds of the anterolateral wall of the cecum, mobilization of the cecum and exteriorization of the injured area as a cecostomy is a quick and safe method of handling the perforation. Later the cecostomy may be closed by a minor extraperitoneal procedure. If the wound is in an area of the cecum not easily exteriorized, it may be closed by two rows of sutures and the bowel decompressed by exteriorizing a segment of the anterolateral wall as a cecostomy. A wound in the region of the ileocecal valve may be treated in the same manner provided it can be closed without impairment of the lumen of the terminal ileum.

If the damage to the right colon is so extensive that resection of the injured segment is the only feasible course, the operating time may be shortened and the hazards of a primary anastomosis in an unprepared colon avoided by exteriorizing the uninjured colon and terminal ileum as a double barrel ileocolostomy. Six patients in this group were treated in this manner. In each case the clamping of the spur was begun within ten days following their injury and all were evacuated to the United States within six weeks with their intestinal continuity restored and with well healed abdominal walls following extraperitoneal closure of their ileocolostomies. The closure of their Mikulicz colostomy is well described elsewhere in this volume. Small

wounds of the remainder of the colon, particularly if they involve the antimesenteric border of the bowel, may be closed by primary suture or the injured segment of bowel may be exteriorized as a loop colostomy. If there is any question as to the security of the closure, such as may occur with wounds of the mesenteric border, the principle of exteriorization is considerably safer. The value of this principle was shown over and over again during the recent war and must be credited with a large share in the reduction of mortality over that for wounds of the colon in World War I.

If the laceration is large or the bowel is divided in order to secure a satisfactory colostomy, as will be necessary in cases with severe wounds of the mesenteric border, subsequent restoration of intestinal continuity will be rendered much simpler and safer if the antimesenteric borders are approximated to form a double barrel spur. Closure of the colostomy by end-to-end anastomosis, which will be necessary if a Mikulicz spur is not formed, is associated with considerably more hazard than an extraperitoneal closure, particularly if the operator's experience in colon surgery is limited. Regardless of which type of colostomy is performed, it should be emphasized here that if a segment of colon is to be exteriorized, it must be exteriorized without tension. If the exteriorized bowel is brought above the surface of the skin under tension, it will inevitably retract, and the morbidity if not the mortality will be increased. Exteriorization without tension as well as the formation of a spur of sufficient length, is dependent upon the initial adequate mobilization of the bowel. The importance of this step in the treatment of injuries of the colon cannot be overemphasized. The method of mobilization and the formation of the Mikulicz spur have been described in a previous volume.¹

There are two fundamental principles in the treatment of injuries to the rectum. First is the establishment of a *proximal colostomy* and the second is adequate drainage of the contaminated perirectal tissues. The sigmoid colon is easily mobilized and a loop or double barrel colostomy may be readily constructed at this site. If the rectal wound is large or is associated with other injuries such as a compound fracture of the sacrum which may prolong the healing of the perirectal wound, it is preferable to divide the bowel completely and to form a Mikulicz spur. The amount of feces which may spill over with this type of colostomy is negligible. On the other hand, it will defunctionalize the rectum for as long as may be necessary and intestinal continuity may be later restored by a relatively minor extraperitoneal procedure. A loop colostomy with an opening on the antimesenteric surface may be used to decompress the bowel if one is concerned about the safety of primary closure of a laceration in the rectosigmoid, but it will not keep feces out of the distal rectal segment, particularly when a slowly healing rectal wound necessitates

the presence of the colostomy beyond four or five weeks. In this group of patients there was an almost unanimous tendency for the loop colostomy to retract after this time permitting more and more feces to spill over into the rectum. This occurred in 8 out of 9 cases of this type and in 7 it was necessary to divide the bowel completely and reconstruct the colostomy to secure healing of the rectal wound.

The contaminated perirectal tissues in the neighborhood of the rectal wound must be adequately drained either through the perineal wound if such is present or by an incision in this area carried down through the fascia propria beyond the tip of the coccyx. Usually this can be done without removing the coccyx. If the coccyx can be left in these patients are much less likely to develop a persistent sinus in this region and they subsequently will have less discomfort on sitting than those patients in whom the coccyx has been removed. No instance of persistent suppuration was found in this group because of insufficient drainage due to leaving the coccyx intact. Three out of 4 patients in whom the coccyx was excised had a persisting sinus leading down to bone lasting three to four months following their injury. The perineal wound in the fourth patient healed satisfactorily but the lower end of the sacrum remained prominent and tender.

There were 4 deaths in this group of 120 patients. One patient died of a pulmonary embolus, the second died of multiple abdominal abscesses following the retraction of his cecostomy, a third died of an exsanguinating hemorrhage from a divided gastroduodenal artery and the fourth from persistent suppuration in the retroperitoneal tissues which failed to respond to surgical drainage and chemotherapy.

Wounds of the colon fortunately are infrequent in peace time. When they do occur they have been associated with the same serious prognosis as they were following battle injuries but I believe that the experience gained during the recent conflict can lead to a similar reduction in the mortality and morbidity associated with peace time injuries of the large bowel.

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RENAL FUNCTION AND MAJOR SURGERY

ROSEMARY A MURPHY AND LEWIS M HURNTHAL

MORE emphasis in preoperative studies should be placed on the evaluation of renal function. At the present time there are available numerous procedures which aid in the determination of the state of renal function. Some are so elaborate that they require considerable time in the hospital before results can be evaluated. It is obvious that many of these tests are unsuitable for use in the routine preoperative studies. Nevertheless, an attempt should be made to determine renal function since poor function is a factor in the choice of the anesthetic agent, it limits the extent of the surgical procedure that can safely be undertaken, and is an added hazard in the presence of depression of blood pressure from anesthesia, hemorrhage or peripheral collapse. Furthermore, it restricts to a certain extent the use of sulfonamide drugs, and necessitates that care be exercised in the administration of fluids and electrolytes.

ESSENTIAL PREOPERATIVE STUDIES AND THEIR SIGNIFICANCE

Although it is not practical to do intricate renal studies preoperatively, it is possible to establish a routine of simple procedures which can be done in any hospital. The first step is to obtain a good history. Information should be obtained concerning nocturia, polyuria and hematuria. A previous history of scarlet fever, frequent streptococcal infections, episodes of edema, known instances of nephritis or pyelonephritis, or toxemias of pregnancy should be specifically sought for.

The physical examination may offer little information. However, the presence of hypertension and changes in the optic fundi may suggest renal disease, while the characteristic pallor and edema may be an indication of severe renal insufficiency.

From the point of view of laboratory investigation two procedures should always be done: (1) a urinalysis consisting of the determination of the specific gravity, qualitative estimation of albumin and sugar, and an examination of a centrifuged sediment for the presence of erythrocytes and casts, and (2) a determination of the blood nonprotein nitrogen.

The determination of the specific gravity is of great importance. If high, the possibility of diabetes mellitus or severe dehydration must be considered and, if present, controlled by appropriate measures. If low, it may or may not be significant. It becomes necessary, however, to determine whether the specific gravity is low persistently.

or only occasionally as the kidneys perform the function of dilution. The simple procedure of limiting fluids for a twelve-hour overnight period and determining the specific gravity of the first morning specimen is of great help. If the latter is not 1.020 or greater it is suggestive of a diminished concentrating ability. In such a case it may become necessary to resort to more elaborate concentration and dilution tests to establish the margin of safety in renal tubular function. A simple test is the measurement of the concentrating ability after the subcutaneous injection of 0.5 cc of pituitrin. Following injection, urine specimens are collected every thirty minutes for at least three hours. A specific gravity of 1.020 or greater is obtained if renal function is normal.

Albuminuria, if of considerable degree, suggests intrinsic renal disease. If of slight degree, it may have no significance and its evaluation depends to a great extent upon the associated findings. The presence of red blood cells and granular or cellular casts in considerable numbers points to active renal disease and necessitates a careful investigation of the patient.

The second most important laboratory procedure is the determination of the blood nonprotein nitrogen. It should be remembered that an elevation of the nonprotein nitrogen does not necessarily indicate irreversible renal insufficiency. Shock, gastrointestinal hemorrhage, diabetic acidosis, congestive heart failure, severe liver disease, and dehydration from any cause may increase the nonprotein nitrogen. On the other hand, an elevated nonprotein nitrogen level may be the sign of an impaired glomerular filtration. If the elevation is caused by one of the former conditions it is important that appropriate measures be instituted to correct them before any surgical procedure is undertaken. The surgical risk in such cases will be determined largely by the nature of the underlying disease. If the increase is renal in origin the operative risk is obviously increased and the extent of surgical manipulations is markedly limited in degree.

In an occasional patient it may be desirable to undertake further studies before the renal status is clearly evaluated. For this purpose, two additional tests are readily available, namely, the phenolsulfonphthalein excretion test (a measure of tubular function) and the urea clearance test (a measure of renal blood flow). Several methods are in use for the phenolsulfonphthalein excretion test, but the most informative is that in which the dye is given intravenously and urine specimens collected at short intervals of time (the so called fractional intravenous method). Certain technical errors must be avoided. An adequate urinary output must be insured by having the patient drink 600 cc of water before the dye is injected. The bladder should be emptied before the test is begun and if there is any question that the patient is unable to empty the bladder completely or has difficulty in

voiding in bed, a catheter should be passed and retained until the test is completed. Specimens should be collected fifteen and thirty minutes after the dye is injected. Ordinarily normal subjects tend to excrete a large proportion of the dye in the early specimens (30 to 50 per cent in the fifteen minute specimen and 15 to 25 per cent in the thirty minute specimen) with decreasing quantities in the subsequent ones, while individuals with impaired function usually excrete a small amount in the first urine and show little tendency to vary during the later periods.

The urea clearance test is less frequently used but often provides desirable information. For this test it is necessary that the laboratory be equipped to determine blood and urine urea. One sample of blood and two specimens of urine are required. This test determines the volume of blood cleared of urea in one minute. Depending upon the rate of urine excretion the result is expressed as the standard or maximal clearance. The standard value is the volume of blood cleared of urea when the urinary flow is at a rate of 2 cc or less per minute and the maximal that in which urine excretion exceeds 2 cc per minute. In the former (standard clearance), values between 40 and 65 cc are considered normal and in the latter, 60 to 100 cc. As a measure of renal impairment this test is more sensitive than the phenolsulfonphthalein test and, if available, is to be preferred.

Briefly, it may be stated that if a patient can concentrate urine to 1020 and has a normal blood nonprotein nitrogen level he is a good operative risk from the point of view of his renal status, and further studies of kidney function are unnecessary.

RELATIONSHIP OF RENAL FUNCTION TO THE CHOICE OF ANESTHETIC AGENT

Certain anesthetic agents have a depressant effect upon renal function. The use of such agents in the presence of renal insufficiency, whether compensated or decompensated, greatly decreases the margin of safety. Ether decreases urine formation which, in some cases, may progress to anuria. Chloroform, also, may cause suppression of urine formation. Vinyl ether and trichlorethylene should be avoided in cases with diminished renal function. Cyclopropane causes a temporary reduction in renal activity but may be the drug of choice. Avertin, which has a wide margin of safety in the presence of normal renal function, loses this margin in the presence of impaired function and should be avoided.

In the postoperative care of patients it is wise to use barbiturates cautiously, if at all, in patients with diminished function. The long-acting drugs, such as barbital and phenobarbital, are largely excreted in the urine, and if secretion of the latter is diminished, sufficient

retention of the usual doses of these drugs may occur to cause severe depression or intoxication.

The use of spinal anesthesia as such is relatively safe in the presence of impaired renal function. However, the fall in blood pressure associated with the use of spinal anesthesia may be dangerous since the diminution in filtration pressure superimposed upon already damaged kidneys may cause decompensation of renal function that is potentially irreversible. Every attempt should be made to maintain the systolic blood pressure at 100 mm or above at all times and vigorous methods should be instituted rapidly to counteract any fall in pressure below this level.

RELATIONSHIP OF RENAL FUNCTION TO PREOPERATIVE PREPARATION

For a rapid routine preoperative evaluation patients may be divided into four groups: (1) those with a normal nonprotein nitrogen and normal concentrating ability; (2) those with an elevated nonprotein nitrogen and a high urinary specific gravity; (3) those with an elevated nonprotein nitrogen and a low relatively fixed specific gravity; and (4) those with a normal nonprotein nitrogen and an impaired concentrating ability.

The patients in the first group may be considered to have normal renal function and need not concern us further. In considering the second group, if an acute nephritis is ruled out, it is safe to assume that the disturbance is extrarenal in origin. Vomiting, diarrhea, hemorrhage, shock, acidosis, alkalosis, or severe infection may be responsible. The exact etiology must be determined by a coordination of the clinical picture and the results of further laboratory procedures such as blood hematocrit and leukocyte count, blood sugar, chlorides, and carbon dioxide combining power, and serum proteins and albumin globulin ratio.

If the patient falls in the third group, it is logical to assume that he has intrinsic renal disease alone or complicated by extrarenal factors and is therefore a poor operative risk. In these individuals it is important to attempt by the appropriate administration of fluids to lower the nonprotein nitrogen to normal or to a fixed level before any surgical procedure is contemplated. The extent to which this is possible will determine the magnitude of the surgical procedures which may be undertaken.

Patients in the fourth group are only fair operative risks. Surgical procedures in such patients should be undertaken with the realization that their kidneys are able to withstand few insults. Fluctuations in blood pressure and water and electrolyte balance which cause reversible disturbances in the presence of normal renal function may rapidly lead to an irreversible state in this group.

RELATIONSHIP OF RENAL FUNCTION TO POSTOPERATIVE COMPLICATIONS

One of the essential features of the postoperative care of a surgical patient is the maintenance of an adequate urinary output determined by an accurate daily measurement. For a patient with normal renal function it has been estimated that nitrogen retention will occur if the urinary output is less than 600 cc in a twenty-four hour period. It is wise, however, to supply sufficient fluid to maintain an output of 1000 to 1500 cc. In those patients whose ability to concentrate urine is impaired, the quantity of urine necessary to prevent nitrogen retention is correspondingly elevated. When the specific gravity is fixed at a low level, a urinary excretion as high as 2000 to 3000 cc daily may be required. Consequently, it is extremely important that a preoperative evaluation of the renal concentrating ability be determined in order to establish a standard for the postoperative urinary output.

A second factor of importance is the ability of the kidneys to handle saline solutions given in the early postoperative period. In the presence of normally functioning kidneys and an adequate protein intake, the administration of saline solutions seldom becomes a problem. Even with normal function, however, lack of protein diminishes the tolerance for saline. The haphazard administration of saline solutions in the presence of impaired renal function adds a burden which the kidneys are unable to meet, edema and in some cases dangerous oliguria or anuria may result.

It cannot be emphasized too frequently that patients with impaired renal function are exceedingly sensitive to extrarenal influences. Hypotension, dehydration from vomiting, diarrhea, or draining fistulas, disturbances of acid base equilibrium, and infection are very poorly tolerated and may rapidly change a compensated to a decompensated renal insufficiency.

RELATIONSHIP OF RENAL FUNCTION TO THE ADMINISTRATION OF SULFONAMIDES

It often is valuable to prescribe one of the sulfonamide drugs prophylactically or therapeutically during the postoperative period. The indiscriminate use of such drugs, particularly in elderly individuals with impaired renal function, may lead to disastrous results. Consequently, it is of greatest importance to know the renal status in any individual to whom such drugs are likely to be administered. Three important points should be kept in mind. First, if a patient has shown evidence of renal decompensation, even if this has been corrected prior to operation, sulfonamides should be given with great caution. The initial dose should be somewhat lower than that usually prescribed (probably about 2 or at most 3 gm) and subsequent doses

not more than 1 gm. every six hours. Fluids should be administered in sufficient quantity to provide a urinary output of 1500 to 2000 cc. daily. Sulfonamide levels, nonprotein nitrogen and a urinary sediment should be checked daily in order that the dose may be varied or the drug discontinued before any complications develop. Second, similar precautions should be taken in any patient whose renal concentrating ability is impaired even if no renal insufficiency has been present. Third, the simultaneous administration of sodium bicarbonate to enhance the solubility of the sulfonamides probably is unwise in the presence of diminished renal function.

Until streptomycin or some similar antibiotic becomes readily available for control of infections which do not respond to penicillin it will be necessary to use sulfonamides in certain patients with subnormal renal function. Whenever this becomes necessary it is essential to realize that they must be administered with caution if serious renal complications are to be avoided.

RELATIONSHIP OF RENAL FUNCTION TO THE CHOICE OF OPERATION

The presence of diminished renal function places a great responsibility upon the surgeon in his decision concerning the advisability of operating or the extent of the operation to be undertaken. An understanding of the functions of the kidneys in the bodily economy and good clinical judgment are essential and must be used in evaluation of the surgical risk of each patient.

Emergency and elective surgery present somewhat different problems. In the former decisions must be made quickly, time for investigation is limited and the condition of the patient often is somewhat precarious. Nevertheless it is under just these circumstances that an accurate evaluation of the situation is most important. Here more than at any other time the necessity for distinguishing extrarenal from renal uremia is paramount. The development of dehydration with its accompanying azotemia and acidosis may lead to a misconception of severe renal disease and a decision not to operate while actually the correction of the primary disturbance by surgical means is an essential feature of the management of the patient. In the absence of uremia no emergency surgical procedure is contraindicated. The occurrence of acute appendicitis, hydrops or empyema of the gallbladder, perforation of a viscus or acute intestinal obstruction must be handled in these patients as in those with normal renal function. In the presence of uremia the problem of emergency operation is fraught with danger and the decision rests upon a comparison of the relative prognosis of the renal condition and the associated disease. If surgical intervention is chosen the operative procedures must

be restricted to the least manipulations compatible with control of the situation.

Elective surgical procedures are generally contraindicated in uremia. They may, however, be undertaken in patients who show no evidence of renal decompensation. It is extremely important that the susceptibility of these patients to extrarenal disturbances be kept constantly in mind. The decision concerning operation will depend upon the magnitude of the patient's symptoms and the predicted outcome if surgical treatment is not undertaken.

The ultimate decision of the surgeon in any case complicated by abnormal renal function must depend upon his evaluation of the prognosis of the renal and nonrenal disease, respectively. He must be cognizant of the limitations which renal impairment places upon the technics available to him. He must understand that no rigid rules-of-thumb can replace an understanding of the course of renal disease and a wise judgment arising from sound clinical experience.

SUMMARY

The importance of determining the presence of decompensated renal insufficiency preoperatively is obvious. No one would deny the limitations which uremia, even of a mild degree, places upon the extent of the surgical procedure that can safely be undertaken. However, the significance of determining the renal margin of safety is not so well appreciated. Too often major surgery is done in patients, not uremic, but with impaired function as evidenced by an inability to concentrate urine. Such patients are not good operative risks. In them, operative and postoperative factors which cause temporary diminution of renal function (anesthesia, hypotension, anemia, vomiting, and so forth) are likely to establish an irreversible state and lead to a fatal outcome.

While it is obvious that it is not practical to do elaborate investigations of renal function preoperatively, it certainly is possible, as well as essential, to determine before any major operation is undertaken the blood nonprotein nitrogen level as well as the concentrating ability of the kidneys. Unless this is done, the appropriate time for, as well as the proper extent of, surgical procedures cannot be determined, nor can the postoperative hazards be anticipated and appropriately treated.

MAJOR SURGERY IN THE ASTHMATIC PATIENT

HARRIET D JAMES, ROSEMARY A MURPHY AND
DONALD M FOWELL

ASTHMATICS, like other people, are subject to diseases which necessitate surgical intervention for their treatment. In contrast to non asthmatics, however, these patients pose certain problems which the surgeon must face at times before and often after he has performed his operation. He may hesitate to operate because of fear of an asthmatic attack or he may operate without an adequate understanding of the complications to which asthmatics are subject or a knowledge of the methods available for preventing or terminating an asthmatic attack.

This paper deals with the important features of asthma from the viewpoint of the surgeon and is based on the study and treatment of a series of asthmatic patients who have been subjected to major surgical procedures.

CLASSIFICATION

The asthmatic state is classified as bronchial asthma (allergic) and asthmatic bronchitis (infectious). This not only differentiates two groups which have certain distinctive etiologic differences, but we feel that they also have a somewhat different prognosis in the face of surgical intervention.

The diagnosis of bronchial asthma is made in a patient with a history of episodes of cough, difficulty in breathing and wheezing respirations which appear to have predominantly an allergic background. This may be indicated by evidence of a family history of allergic diseases or the history of the patient may reveal previous or concomitant allergic states such as vasomotor rhinitis, nasal polyps, hay fever, eczema, urticaria and food allergies. There may be known or strongly suspected precipitating factors.

The diagnosis of asthmatic bronchitis, on the other hand, is reserved for those cases in which the allergic aspects are absent or less marked, and the available evidence suggests an infectious origin. These patients often give a history that the initial attack followed an upper respiratory or pulmonary infection and that subsequent episodes frequently were precipitated by similar conditions. They usually are prone to respiratory infections and may constantly have a low grade bronchitis. Occasionally bronchiectasis is present. The average patient with asthmatic bronchitis tends to fall into a somewhat older age group than does the patient with bronchial asthma.

TREATMENT OF AN ASTHMATIC ATTACK

Hospitalization.—If operation is contemplated on a patient who is having asthmatic attacks, it is important to hospitalize him for treatment of the asthma rather than to attempt to control the attack at home before hospitalization. This provides many features of importance in the rapid control of the patient. It removes him from his home surroundings which often contain many psychic and physical factors which act as precipitating agents. The patient is placed in a quiet environment and rest can be imposed. Visitors can be kept at a minimum and the diet controlled. Often it is possible to obtain an air conditioned, constant temperature room which tends to minimize such aggravating factors as dust and fluctuations in temperature and humidity.

Diet.—The diet should be easily digestible and free from any foods proved or suspicious, to which the patient is sensitive. If the attack is severe, it may be a tax upon the patient's endurance to attempt to eat regular sized meals. In this case it is desirable to provide him with smaller and more frequent feedings.

Sedation.—Adequate sedation is of utmost importance. If the patient has no idiosyncrasy for the barbiturates, phenobarbital in doses of $\frac{1}{4}$ to $\frac{1}{2}$ grain three times daily with seconal, $1\frac{1}{2}$ grains, or nembutal, $1\frac{1}{2}$ grains, at night has been found to be satisfactory in most cases. Chloral hydrate, 30 grains by rectum, is an alternate medication which provides satisfactory sedation at night.

Antispasmodics.—Epinephrine (1:1000) may be used in doses of 4 minims with great benefit. Others have used larger doses but we feel that such doses may cause undesirable systemic effects. In certain cases epinephrine in oil may be used to prolong the effect. Occasionally a patient may obtain relief from the inhalation of $\frac{1}{100}$ epinephrine when he obtains poor results from injected epinephrine. A valuable drug to be used alone or in conjunction with epinephrine is aminophylline. This can be given intravenously in doses of $3\frac{3}{4}$ grains to $7\frac{1}{2}$ grains. It should be administered very slowly. Rapid injection is often followed by a sense of giddiness, marked apprehension, and palpitation. It may be given rectally in a small amount of water or in the form of a suppository. We find that the combination of aminophylline and chloral hydrate given rectally at night often makes it possible for the patient to obtain a restful sleep. Combinations of ephedrine, phenobarbital and aminophylline in capsule or tablet form taken every three or four hours may control symptoms.

Expectorants.—The bronchial secretions in asthmatics tend to be thick and tenacious. Attempts to expectorate them are ineffective and exhaust the patient. For this reason it is wise to attempt to thin the secretions by the administration of potassium iodide or ammonium chloride. The former is given as 10 to 15 drops of a saturated solution.

and the latter as 7½ to 15 grams (enteric coated tablets) three to four times daily

Chemotherapy.—The use of penicillin aerosol may be of considerable benefit especially in patients with asthmatic bronchitis. A total of 100 000 units is dissolved in 3 cc of normal saline solution. 0.5 cc. of this solution placed in a nebulizer which is attached in a circuit from an oxygen tank is inhaled six times daily. The oxygen is given at a rate of 7 to 8 liters per minute. Although this method of treatment does not effect permanent cures of the bronchial infection, it often gives marked temporary relief which may tide the patient over the operative period.

SPECIAL PROBLEMS RELATED TO ASTHMATICS

Anesthesia—The choice of an anesthetic agent presents no difficult problem in an asthmatic patient. The criteria for the choice are essentially the same as in nonasthmatics. There is no reason to feel that there is any danger inherent in the use of inhalation anesthetics should these be considered desirable for the contemplated surgical procedure. It is a well known fact that the administration of ether by rectum often gives great relief to a patient who has become refractory to other forms of therapy. Similarly, ether by inhalation will control an asthmatic episode.

With the induction of general anesthesia, the asthmatic attack comes under control at least for the period of the operation and frequently for a longer period of time. Bronchial spasm is eliminated. Secretions may persist but these should present no greater problem to the anesthetist than the secretions in a nonasthmatic patient and in turn, they are treated in an identical manner.

Following the operation the responsibilities of the anesthetist are the same as for any patient. An airway must be maintained, secretions must be kept thin and removed by periodic coughing or by suction if necessary.

Morphine—The use of morphine is contraindicated in patients with bronchial asthma since it depresses respiration, diminishes or abolishes the cough reflex and causes bronchial constriction. These effects superimposed upon the respiratory difficulty of an asthmatic have been known to lead to a fatal outcome. In asthmatics with recent attacks or in whom there is danger of a postoperative exacerbation, morphine should not be used either as a preoperative medication or as a postoperative analgesic or sedative. As a substitute for morphine the synthetic drug demerol may be used. This drug has analgesic, antispasmodic and sedative properties. In contrast to morphine it has little depressant effect upon the respiratory center and causes bronchial relaxation. A dose of 100 mg is approximately equivalent to ⅙ grain of morphine. Demerol may be used as an adjuvant in the

treatment of the acute asthmatic attack as well as in the routine preoperative and postoperative medications

Cough.—The presence of cough may be a serious difficulty in the postoperative period. The frequent, often intractable, spasmodic cough of a severe asthmatic would certainly be a great strain on fresh incisions. This is one reason for the desirability of controlling an asthmatic attack prior to operation and preventing recurrences during the postoperative period. Nevertheless, complete suppression of a cough, as by morphine, is as undesirable in an asthmatic as in a nonasthmatic. In either type of patient complete suppression of the cough reflex by heavy postoperative medication undoubtedly contributes in many instances to the development of such complications as atelectasis and pneumonia. Bronchial secretions should be kept fluid by the use of ammonium chloride or potassium iodide and the patient encouraged to cough very moderately at regular intervals. Attempts to prevent secretion by the use of atropine are not wise since the presence of thick, tenacious sputum may lead to occlusion and atelectasis.

Chemotherapy.—The introduction of specific chemotherapy added a valuable adjunct to the preoperative and postoperative care primarily of the patient with asthmatic bronchitis. The increased susceptibility of these patients to postoperative atelectasis and pneumonia is adequate reason for the prophylactic use of one of the sulfonamides or penicillin. If one of the sulfonamides is chosen it is imperative to determine by specific questioning whether the patient at any previous time has shown any sensitivity to the drug. Full doses should be given for twenty-four hours prior to operation in order that an adequate level be obtained by the time the operation is performed. Penicillin is easier to administer to the postoperative patient and may be the drug of choice. The length of time that the drugs should be continued must be determined by the condition of the patient.

If facilities are available, the ideal scheme is to administer penicillin by inhalation for two days before operation and then to continue it by intramuscular injection postoperatively until the danger of infection has passed.

POSTOPERATIVE COMPLICATIONS

The most important postoperative complications in asthmatic patients are (1) atelectasis, (2) pneumonia, and (3) acute asthmatic episodes. Prophylaxis against these complications assumes considerable importance. The postoperative routine of hourly turning of the patient, deep breathing exercises, and regular but moderate coughing should rigidly be enforced.

Any elevation of temperature or pulse, whether or not accompanied by an elevation of respiration, occurring within the first twenty-four to forty-eight hours should be considered as suspicious evidence of

atelectasis This should be checked immediately by roentgenologic examination of the chest and, if verified, bronchial aspiration should be considered Bronchial secretions should be stimulated by the oral or rectal administration of potassium iodide, and bronchial relaxation induced by the subcutaneous administration of epinephrine Penicillin

after the second day

upon an unrecognized

I patchy atelectasis The previously outlined therapy should be instituted including full doses of one of the sulfonamides or penicillin The occurrence of a severe asthmatic attack in the postoperative period is a serious complication Every effort should be made to prevent such episodes In severe asthmatics it may be wise to administer aminophylline intravenously or rectally two or three times daily prophylactically Careful observation should be made to detect early undue coughing or slight wheezing in order to institute therapy to abort a severe attack Should such an attack develop, every effort must be made to establish control as rapidly as possible

Although all asthmatic patients should be carefully watched postoperatively, particular caution should be exercised in the care of those considered to have asthmatic bronchitis In our series of operative cases this group showed three times as many complications after operation as were seen in patients with noninfectious bronchial asthma

EMERGENCY VERSUS ELECTIVE SURGERY

Elective surgical procedures may be performed on almost all asthmatic patients Occasionally, patients are encountered in whom the disease is so extremely severe or of such long standing or in whom the psychic factors are so prominent that they are refractory to all forms of therapy In such cases the asthmatic state becomes the predominant disease and the surgical condition secondary In them any surgical procedure is extremely hazardous The greater number of asthmatics however, are suitable for elective operations Nevertheless in view of the elective nature of the operation all such patients should be controlled from the point of view of the pulmonary disease before any surgical treatment is undertaken When this stipulation is carefully adhered to and when the surgeon is alert to the nature of the potential postoperative complications and their greater incidence in the infectious group, the occurrence of untoward reactions will be significantly lowered

Emergency operations present a more serious problem to the surgeon It is conceivable that a situation may arise in which time is at a premium and any delay may lead to a fatal outcome Under such circumstances heroic measures must be instituted to treat the patient simultaneously by both medical and surgical means In situations such

as this, the coordinated teamwork of the surgeon and the internist is of the utmost importance and may determine the ultimate outcome. The induction of general anesthesia may be the most important factor in the immediate control of the asthmatic attack. Subsequent to the operation care must be exercised to prevent a recurrence.

In many so called emergency operations a delay of one to several hours may not endanger the life of the patient. During this period the available therapies should be intelligently utilized. Often it will be found that while the operative decision is being made and the surgical equipment set up, the asthmatic patient can be prepared for operation. This time is extremely valuable and never should be wasted. No harm comes to the patient if his asthma is controlled and the surgical opinion is one of nonintervention while the opposite set of circumstances may change the course of events.

SUMMARY

For the purposes of this paper, asthma is classified as (a) bronchial asthma denoting a predominantly allergic background, and (b) asthmatic bronchitis, indicating principally an infectious background.

Treatment of an asthmatic attack is outlined, under the headings hospitalization, diet, sedation, antispasmodics, expectorants and chemotherapy.

Special problems related to the asthmatic patient are discussed. Criteria for the choice of the anesthetic are the same as for non asthmatics. The use of morphine is contraindicated, demerol is a satisfactory substitute. The intractable asthmatic cough must be controlled, but postoperatively, the cough reflex must not be abolished. It is suggested that in cases of asthmatic bronchitis penicillin aerosol be given preoperatively, followed by penicillin by injection postoperatively.

Postoperative complications in asthmatic patients are principally atelectasis, pneumonia, or acute asthmatic episodes. In all asthmatic patients operated on at the Lahey Clinic in the last five years, these pulmonary complications were three times as frequent in cases of asthmatic bronchitis as in cases of bronchial asthma, emphasizing the importance of classification.

Elective surgical procedures give ample time preoperatively for complete control of the asthmatic state. Emergency surgical conditions naturally take precedence over the pulmonary disease, but in such a situation the need for complete and immediate cooperation between surgeon and internist cannot be overemphasized.

BLOOD TRANSFUSION IN MAJOR SURGERY: FACTORS OF SAFETY

DONAT P. CYR

WITH the development of blood banks, transfusion of whole blood has become such a common practice that physicians are prone to lose sight of the fact that, although a blood transfusion is often a life saving measure, it can also be a serious threat to life itself. Too often a transfusion is given without a definite indication. To expose a person to the dangers of a blood transfusion is not justifiable when there is no other reason than "to give the patient a boost" or because an individual "looks sour" following a major operation.

INDICATIONS FOR TRANSFUSION IN SURGERY

In major surgery the usual indications for the administration of whole blood are (1) to supply oxygen carrying red blood cells, (2) to prevent or combat shock by maintaining or increasing the blood volume, (3) to contribute those substances necessary to make up certain deficiencies in the clotting mechanism, and (4) to help combat infection by supplying immune bodies to patients suffering from septicemia or other serious infections.

To be successful therefore, a transfusion of whole blood must satisfy a definite physiologic need as outlined. In addition, it must not harm the recipient.

TRANSFUSION REACTIONS AND COMPLICATIONS

The reactions that may occur following the intravenous administration of whole blood may be divided into five groups: (1) intravascular hemolysis, (2) simple febrile reactions, (3) circulatory and vascular disasters, (4) transmission of disease, and (5) allergic reactions.

Intravascular Hemolysis.—Intravascular hemolysis is by far the most serious consequence of a blood transfusion. It usually results from the administration of incompatible blood, it may occur following transfusion of blood that has been stored too long.

The phenomenon of hemo agglutination presupposes the presence in the same circulation of an agglutinin found in the red blood cells and a biologically incompatible agglutinin present in the plasma or serum. This reaction may occur under a variety of circumstances and will be presented as follows: group incompatibility, subgroups of A and AB, use of group O individuals as universal donors, and Rh factor.

GROUP INCOMPATIBILITY—Landsteiner, in 1900, discovered that the blood of humans can be divided into four groups. The basis for this division of human blood is the presence or absence in the red cells of two agglutinogens A and B, and of two agglutinins, alpha and beta, found in the plasma or serum. According to the International Nomenclature blood is classified into

- 1 Group A—A agglutinogen and beta agglutinin
- 2 Group B—B agglutinogen and alpha agglutinin
- 3 Group AB—A and B agglutinogens and no agglutinins
- 4 Group O—both alpha and beta agglutinins but no agglutinogen

It is essential in every blood transfusion that neither the donor's corpuscles shall be agglutinated by the recipient's serum nor the recipient's corpuscles agglutinated by the donor's serum. It is necessary, therefore, to determine the agglutinogen content of both the donor's and the recipient's red blood cells (blood grouping—indirect test of compatibility) and to ascertain that the serum of the recipient does not agglutinate the cells of the donor (cross matching—direct test of compatibility). Rarely is it necessary to do the so called "minor agglutination" i. e. testing the donor's serum against the recipient's red cells.

The technique of blood grouping and cross matching has been fully described in several textbooks and laboratory manuals and need not be discussed here. It should be noted, however, that many pitfalls exist in the proper grouping and cross matching of blood.

Pseudo agglutination—This term refers to the grouping of red blood cells in rouleaux fashion, resembling a pile of coins. The phenomenon is commonly observed and may be misinterpreted as true agglutination. Rouleaux formation is accentuated in infectious conditions associated with an elevated sedimentation rate. Both phenomena are related to changes in the globulin fraction of the plasma proteins.

Pseudo agglutination can be almost entirely eliminated by diluting the patient's serum. Hence it is rarely observed if cross matching tests are done by the test tube method. A slide preparation should be gently tapped and examined microscopically. Gentle tapping will cause the small aggregations of red cells to disintegrate whereas it will not affect true agglutination.

Auto agglutination—Auto agglutination may be defined as the ability of an individual's serum to agglutinate his own red blood cells. It is a true antigen antibody reaction in contrast to pseudo agglutination. The agglutinin is a "cold" agglutinin which is usually active only at low temperatures. It is commonly present in normal sera (32 per cent according to Shooter), but rarely is the titer of such degree as to offer any difficulty in the tests of compatibility performed at room temperature. In certain diseases such as cirrhosis of the liver, hemolytic anemia of the acquired type, paroxysmal hemoglobinuria

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The practical importance of the subgroups is as follows: They may lead to confusion in blood grouping. Because of the low sensitivity of the agglutininogen A_2 , group A blood (subgroup A_2) may be interpreted as group O (no agglutination with either of the typing sera). Also, group AB (subgroup A_2B) may be mistaken for group B (questionable agglutination with anti-B serum but no agglutination with anti-A). This emphasizes the necessity of using typing sera of high titer.

In occasional cases when alpha-1 and alpha-2 are of relatively high titer, reactions may occur when A_1 blood is given to A_2 recipients or vice versa. Such reactions are rare and usually result in mild reactions in the case of a first transfusion. However, an antigen has been introduced which boosts the titer of the existing antibody and possibly stimulates the production of an antibody which perhaps may not be present. With subsequent transfusions of blood from the same donor, a severe and even fatal reaction may occur as the result of previous iso-immunization. Such accidents have been reported and explain some instances of intragroup reactions when dealing with group A blood.

It must be appreciated that from a practical standpoint, the subgroups are of no significance in a first transfusion. With repeated transfusions and during pregnancy and the puerperium, the danger of a serious accident is real. The greatest safeguard against subgroup incompatibility is the use of typing sera of high titer. Methods of recognition of the subgroups have been described and are applicable in rare instances.^{3, 4, 5, 16, 17}

USE OF GROUP O INDIVIDUALS AS UNIVERSAL DONORS.—When group O blood is given to an individual of other groups, agglutinins alpha and beta are introduced into the circulation of the recipient. As a rule, such a transfusion is unaccompanied by a reaction because the donor's agglutinins are of low titer and are diluted by the plasma of the recipient. In rare instances when a large quantity of blood is given to an exsanguinated recipient with lowered blood volume, a severe reaction may result.

Some individuals have high titer agglutinins. The use of such blood may be disastrous in a heterologous transfusion unless the agglutinins are neutralized by the addition of A and B substances which are now available from certain pharmaceutical houses.

Coca states that a high titer agglutinin is present in 3 per cent of group O donors. According to Hesse, the incidence is 30 per cent.

It is also theoretically unsafe to administer group O blood to subgroups A_1 and A_2B since the plasma of these individuals may contain high titered alpha-2 agglutinin which has the property of agglutinating O cells.

From these considerations it becomes apparent that the concept of

safety of group O blood as universal blood is erroneous danger, of course arises from the use of O blood with lutinins. Because of this a regulation has been introduced Code of New York State that the titer of agglutinins of

viduals to be used as universal donors must be determined by actual titration. Except in an emergency, it is best to use homologous^{2, 4, 15} transfusions.

RH FACTOR—For many years reactions have been known to occur following the administration of homologous blood when grouping and cross matching tests showed no *in vitro* incompatibility. Only a very small number of these accidents could be attributed to subgroup incompatibility. Since the discovery of the Rh factor by Landsteiner and Wiener (1940) most intragroup reactions have been shown to result from Rh incompatibility.

The Rh factor is an agglutinin present in the red blood cells of 85 per cent of the white population (Rh positive). Fifteen per cent of the people have no Rh agglutinin (Rh negative). When Rh positive blood is given to an Rh negative individual the agglutinin Rh stimulates the production of anti Rh iso immune bodies in the plasma of the recipient. Similarly, an Rh positive fetus stimulates the production of anti Rh agglutinins in the circulation of an Rh negative mother.

Not all Rh negative individuals become sensitized after repeated transfusions of Rh positive cells. Diamond found that only 6 out of 10 Rh negative males developed anti Rh agglutinins of significant titer after repeated transfusions with Rh positive blood. An Rh positive fetus is a more potent iso immunizing agent and, therefore, the Rh factor plays a much more important role in Rh negative females during pregnancy and the puerperium. Evidence is accumulating to show that anti Rh immune bodies may be present in the circulation of an Rh negative individual for months or even years after sensitization.

From these facts it can be readily understood that the administration of Rh positive blood to an Rh negative mother during pregnancy or the puerperium may lead to a hemolytic reaction and if the anti Rh agglutinins are of sufficiently high titer, a fatal accident may result. For the same reason repeated transfusions of Rh positive blood to an Rh negative individual may lead to hemolytic reactions which are usually mild to moderate in severity but rob the patient of the benefit of the transfusions and in some instances result in anuria. One or more transfusions given to an unmarried Rh negative female may decrease her chances of having one or more normal pregnancies in the event that she marries an Rh positive male.

With a single transfusion the Rh factor is of no importance except during pregnancy. Ideally, it is advisable to do Rh determinations in all transfusions. From a practical standpoint, this is not possible because anti Rh agglutinins of high titer necessary for typing the Rh

factor are not easily available. Nevertheless it must be strongly emphasized that should repeated transfusions be necessary or if a transfusion is required during pregnancy, the Rh factor of the recipient must be known or only known Rh negative donors must be used.

Even after all the conditions of compatibility have been fulfilled, transfusions are not without danger. Some reactions are mild and of no significance, others may be more severe and lead to fatal results.^{7, 17}

Simple Febrile Reactions.—A small percentage of febrile reactions are due to incompatibility either because of errors in grouping or because of intragroup incompatibility. Fortunately, not all transfusions of incompatible blood result in fatalities. Nevertheless, even a mild reaction requires an explanation. The tests of compatibility should be rechecked, for if blood of the wrong group has been given, a subsequent transfusion of blood of the same group or from the same individual will almost certainly result in a more severe and even disastrous hemolytic reaction.

The majority of febrile reactions with or without chills are due to the introduction of a foreign protein, dead or living but nonpathogenic organisms, from the apparatus or from the various transfusion fluids. The importance of using fresh pyrogen free distilled water, the necessity for scrupulous cleanliness and for immediate and proper cleansing of all apparatus and proper autoclaving of solutions used in transfusion work have been emphasized by Lewisohn and Rosenthal. These authors have shown that with proper technic the incidence of chills and fever from these causes can be reduced from 12 to 1 per cent.

Mild febrile reactions may occur due to coagulative changes in the transfused blood. These can be prevented by proper straining and by assuring a free flow of blood through a large gauge needle properly inserted into the vein.

The introduction of closed systems in the collection of blood has greatly reduced the incidence of contamination. This danger is forever present unless scrupulous asepsis is observed in drawing blood, especially if this is done by the open flask method. However, most contaminating organisms are nonpathogenic and their growth can be inhibited by immediate cooling in the refrigerator and by not allowing the blood to stand too long in a warm room before its administration.

It must be emphasized that, whereas febrile reactions due to the various causes mentioned are usually mild, they may be severe and offer much difficulty in distinguishing them from the more dangerous hemolytic reaction. Also, in greatly enfeebled patients and in individuals with cardiovascular or pulmonary disease, any but the mildest reaction may precipitate a fatal ending.

Circulatory Accidents.—The rapid injection of 500 cc of blood into the circulation of the average adult individual without heart disease is well tolerated. Following an acute severe hemorrhage with

marked lowering of blood volume several liters of blood may be administered fairly rapidly without precipitating pulmonary edema. In such instances a rapid restoration of the blood volume far outweighs the danger of circulatory overloading. It is well to remember, however, that the too rapid administration of a blood transfusion may produce a rigor.

In elderly patients with weakened myocardia, in individuals with chronic and severe anemia, and in persons enfeebled by chronic disease, the situation is much different. In such patients the danger of producing pulmonary edema and death from circulatory failure is real and must be guarded against. In DeGowin's series 2 out of 7 deaths following transfusions were the result of pulmonary edema.

With the exceptions mentioned, the average rate of intravenous administration of blood by the drip method should not exceed 1 cc per pound of body weight per hour. Thus the usual transfusion of 500 cc of blood would require about three to four hours with the flow adjusted at 60 to 80 drops per minute. If the patient has known heart disease or pulmonary embarrassment, if the anemia is very severe and of long standing the rate of flow should be 30 to 40 drops per minute.

When preparing a patient with chronic anemia for operation, it is desirable to raise the hemoglobin level to at least 80 per cent. On the basis that 1 pint of blood will increase the hemoglobin value by 10 per cent, some patients will require two or more transfusions. It is well to remember that patients with weakened myocardia from severe anemia of long standing will not tolerate large quantities of blood even if given slowly. It is necessary to divide the transfusion and give a smaller amount of blood at intervals of one to two days, depending upon the condition of the individual patient. In this connection it may be said that a transfusion under anesthesia offers no additional danger other than that which may result from incompatibility.

Transmission of Disease.—Careful questioning and examination of the donor must precede every blood donation. Early seronegative as well as latent seropositive syphilis may be transmitted to the recipient unless the donor is examined carefully and serologic tests are performed. Fortunately, the transmission of syphilis by transfusion is rare.

With the return of so many potential donors from malarial countries greater precautions than ever must be exercised to prevent the transmission of malaria to the recipient of a blood transfusion. Ideally it is best not to use a donor who gives a history of malaria in view of the long latency of this disease. In addition, the donation of a pint of blood has been known to activate a latent malarial infection in the donor.

In recent years reports have accumulated with regard to the transmission of virus infections resulting in hepatitis and jaundice. Only a careful history can prevent this from occurring. These possibilities

emphasize the wisdom of giving a transfusion only when it is genuinely indicated.

Allergic Reactions.—Foreign proteins to which the recipient may be naturally sensitive or to which he may develop a hypersensitivity may lead to reactions varying in degree from anaphylactic shock to mild urticaria. Usually such allergic reactions are not severe and can be immediately alleviated by the subcutaneous injection of 5 to 15 minims of a 1:1000 solution of epinephrine. The incidence of allergic reactions can be reduced by insisting that the prospective donors be in the fasting state for four hours prior to withdrawing the blood.^{8, 12, 15, 16, 17}

USE OF STORED BLOOD

In recent years there have been many studies done on the therapeutic usefulness of stored blood as compared to fresh blood. Even though blood banks have greatly widened the scope of blood transfusion as a therapeutic measure, one must not lose sight of the fact that the more readily available stored blood undergoes certain chemical and morphologic changes which render it less efficacious in fulfilling the specific physiologic need for which the transfusion is intended.

Fresh blood and citrated blood stored for only a few days supply physiologically active red blood cells which survive in the recipient's circulation for three to four months. After two to three days of storage the erythrocytes begin to disintegrate and in seven to ten days the oxygen-carrying capacity of such cells is greatly reduced so that the therapeutic result desired is no longer fulfilled. Recent studies have shown that a glucose-citrate mixture buffered with sodium phosphate to a pH of 7.4 is a more satisfactory blood preservative than citrate alone. After two weeks of storage, blood preserved in this mixture supplies red blood cells which survive in the recipient's circulation for at least forty-eight hours after transfusion.

One or more preoperative transfusions are sometimes desired to supply platelets to an individual with thrombocytopenia prior to splenectomy. The physician must bear in mind that platelets have almost completely disappeared from stored blood in twenty-four to forty-eight hours. The use of fresh blood in such instances is a necessity in order to increase the coagulability of the recipient's blood.

Leukocytes disappear from the blood after only a few hours of storage. The immune bodies contained in the globulin fraction of the plasma are still efficacious even after many days of storage. When a transfusion is used to help combat infection, however, it is best to use fresh blood since blood freshly drawn or blood only a few days

SUMMARY

Fatal transfusion accidents can almost entirely be eliminated if the following rules are observed

1 Ascertain that the blood of the donor and of the recipient are properly grouped according to the four major blood groups This of necessity requires high titer typing sera

2 Do careful cross matching before every transfusion except in dire emergencies

3 Use homologous blood in preference to the group O universal donor

4 With repeated transfusions or during pregnancy and the puerperium the Rh factor must be determined or only known Rh negative donors should be used

5 As an additional precautionary measure do the so called "biologic test," i.e. observe the patient carefully during the administration of the first 50 to 100 cc of blood

6 Evaluate the cardiovascular status of the recipient so as not to overload his circulation

7 Choose the donors carefully with regard to previous or existing transmissible diseases

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METASTASIS TO BONE IN GASTROINTESTINAL MALIGNANCY

GEORGE L. THOMAS

THE incidence of metastasis to bone in primary malignancy of the gastrointestinal tract is relatively rare. In a series of 168 cases of metastatic carcinoma of the bony skeleton recently studied at the Clinic, we have noted the primary source in the gastrointestinal tract in only 11 cases. This constitutes an incidence of 6 per cent.

In most instances bony metastasis has been a late complication and has been noted in the terminal or near terminal phase of the disease. The female breast and the prostate gland have been the primary sites of skeletal metastatic carcinoma in the group of cases studied.

The management of the patient with malignant disease of the gastrointestinal tract which has metastasized to the skeleton is often limited to comparatively simple procedures designed to relieve pain in the terminal phase of the disease. An occasional case, however, requires the combined effort of our several departments in an attempt to make the patient as comfortable as possible. We believe the effort is worth while if we are able to spare the patient as little as a few months' suffering. The following case report is informative in that it demonstrates the problem which not infrequently confronts the physician who is obliged to manage patients with this disease.

CASE REPORT

An unmarried 69 year old woman was admitted to the New England Baptist Hospital in February 1945. She complained of a painful right leg which developed after a fall from a chair to the floor. Examination revealed the usual deformity of a fractured right hip as well as a large abdominal mass in the right lower quadrant. The patient had noted a 7 pound weight loss in the preceding three months and had complained of intermittent abdominal cramping for a year.

Roentgenologic examination revealed an intertrochanteric fracture of the right hip and pathologic bone suggesting metastatic carcinoma of the upper right femoral shaft. A barium enema established the presence of a large filling defect in the rectum characteristic of primary carcinoma at this site.

Laboratory examinations showed a severe hypochromic anemia, leukocytosis and an elevated basal sedimentation rate.

Russell traction was applied to the right leg and a satisfactory reduction of the fracture was accomplished. Figure 296 *a* and *b* demonstrates the intertrochanteric fracture before and after reduction by means of Russell traction. Under ordinary circumstances we would have considered traction a sufficient treatment for the fracture shown. However, since abdominal surgery was indicated it was necessary to apply internal fixation of the fracture in spite of the pathologic bone noted in the upper femoral shaft. The patient was given 3500 cc. of citrated whole blood intravenously over a period of seven days. When her general condition was



Fig 296—Intertrochanteric fracture *a*, Before reduction, *b*, after reduction



Fig 297—*a*, Intertrochanteric fracture following internal fixation. Arrows indicate area of pathologic bone
b, Healing intertrochanteric fracture. Pathologic bone still visible in upper femoral shaft

satisfactory she was taken to the operating room where internal fixation was applied to the fracture by means of a Lorenzo screw and a femoral plate as shown in Figure 297 *a*. The immediate postoperative course was entirely satisfactory and the patient was completely comfortable as far as the fracture was concerned on the third postoperative day.

Twelve days later the abdomen was explored and a right colectomy with a primary side-to-side ileotransverse anastomosis was performed. The postoperative course was again uneventful with one exception. Five days later thrombophlebitis developed involving the left lower extremity. This complication responded to left paravertebral sympathetic block which was carried out three times.

There were no further complications and the patient was discharged on the seventy-seventh hospital day. X-ray treatment was given at the site of metastasis in the right femoral shaft. The patient has been completely comfortable for more than a year. She has gained weight and is able to stand and walk on her right leg with no discomfort whatsoever. A more recent roentgenogram of the right hip taken in October 1945 is shown in Figure 297 *b*. It will be noted that she has abundant callous formation and there is little evidence of either osteoblastic or osteolytic activity at the site of the former upper femoral shaft lesion. Periodic roentgenograms of the chest have revealed no evidence of pulmonary involvement. For the past several months the patient has been able to care for herself and is delighted with her present situation.

Ordinarily the treatment of skeletal metastasis is of course, strictly palliative and is designed to relieve pain. Painful metastases to the spine have been treated by radiation and cordotomy, and these methods have been effective as temporary measures in some cases. Bony metastasis however has occurred frequently as a near terminal complication and most of our patients have required morphine in large doses. It has been possible to reduce the terminal suffering in many instances by combining irradiation with adequate doses of morphine, dilaudid or pantopon. We have used cobra venom with some success but have recently discontinued the use of this agent. By means of careful timing and adequate medication many patients have been spared much of the pain which invariably accompanies the terminal phase of this disease. On the other hand it will be noted from the case report that in an occasional instance active treatment is warranted in spite of the fact that the surgical procedures involved are often extensive and require thorough preparation as well as meticulous postoperative care.

UROLOGIC COMPLICATIONS FOLLOWING LARGE BOWEL SURGERY AND THEIR MANAGEMENT

EARL E EWERT

URINARY tract complications play so important a part in the management of patients following operations on the large bowel that it seems worth while to discuss the problems involved in managing them. In our analysis it was found that nearly 30 per cent of this special group had some form of genito urinary complication. Although this ratio seems very high, it is so because 28 per cent of these patients had urinary findings indicating infection with or without symptoms. Many of this group were found to be free of symptoms on their first or second postoperative visit, nevertheless, they were included because of their urinary findings on discharge from the hospital.

Urinary tract complications arise by virtue of several factors, primarily, and it is not difficult to comprehend this. One factor is contiguous extension, particularly when the growth involves the sigmoidal or rectal segment, the bladder, seminal vesicles and the prostate. The second factor is the removal of the sigmoid with the exposure of the ureters lying to either side of the sigmoid mesentery and then the direct surgical attack upon the lesion whether it involves the bladder, the seminal vesicles or the prostate. Lesions of the ascending or descending colon are not nearly so likely to involve the kidneys and, accordingly, we have found the genito urinary complications far less common in this group. Because the operability rate of carcinoma of the rectum has steadily risen at the Clinic until it now stands at 85 per cent, it is reasonable to assume that aged patients and patients subjected to radical operations will need closer postoperative care with regard to their genito urinary system than in the past. From the

TABLE 1 — AGES OF 54 PATIENTS HAVING TRANSURETHRAL SURGERY

Rectal Segment (50 Cases)		Nonrectal (4 Cases)	
Average age	65 years	Average age	65 years
Youngest	32 years		
Oldest	77 years		

viewpoint of the urologist, the male members of this class demand more careful supervision and I wish to deal more intimately with their problems (Table 1).

Since most of the male patients who have removal of the rectal segment are in the prostatic age, they have to surmount several handi-

caps in their postoperative course in order to urinate. Removal of the rectal segment in many instances alters the anatomy of the bladder. The bladder floor descends and this patient develops to some extent a male cystocele. The angle at which his trigone approaches the bladder neck is made more acute and its action in opening the bladder is seriously interfered with. There is also to our mind a lack of fixation of the bladder floor produced by the necessary dissection so that at times the bladder is fastened only at the vesical neck. The second factor in bladder dysfunction in dealing with males, is the detrusor paralysis from parasympathetic denervation when the posterior bladder wall and floor are exposed. The third hurdle a male in the prostatic age has to overcome is the vesical neck obstruction which may be present to a greater or less degree. The last factor is the urethral resistance present in the male that, while not great, is of some importance in a patient who may be debilitated by his carcinoma and his recumbent position in bed.

From our experience, the initial *detrusor paralysis* has for the most part disappeared when the urethral catheter is removed. This period however, can be prolonged when the weakened bladder musculature has to compete with vesical neck obstruction, urethral resistance and a loss of anatomical support of the bladder floor. It is not always possible to estimate the pure examples of each but they may be classified as follows:

- 1 Pure detrusor paralysis from parasympathetic denervation
 - a A mild form cystometrically evident in large numbers of patients the first week following operation
 - b A severe form necessitating prolonged tidal drainage present in a small number
- 2 Mixed forms of detrusor paralysis in combination with
 - a Vesical neck obstruction
 - b Almost complete loss of anatomical support and lack of fixation
 - c Inherent resistance in the male urethra
- 3 Vesical neck obstruction alone

All patients undergoing abdominoperineal resection are placed on catheter drainage and this indwelling catheter is maintained until some time after the seventh postoperative day. It would seem, therefore, important in managing a patient who fails to void after his catheter is removed, or who voids infrequently, or who develops a fever shortly after the catheter has been removed, that the cause of his urologic difficulty should be quickly assayed so that temporizing measures will not only not delay his hospital stay and possibly decide a surgical victory or defeat.

This preparation for possible urologic complications in the male should take cognizance of the fact that particular attention should be paid to the presence or lack of urinary difficulty prior to operation. It is almost certain that a patient in the prostatic age who has marked

difficulty in urinating will need some relief after his more urgent abdominoperineal resection. It is also essential that the size of the prostate be noted in the history and needless prolonged catheter drainage be avoided or repeated insertion of the catheter be eliminated in attempting to get the patient to urinate against the marked prostatic obstruction. This is well illustrated by the following case.

CASE I.—A man aged 65 gave a history of having had some urinary difficulty for the past ten or fifteen years consisting of nocturia three to four times, diminution in size and force of stream, hesitancy and dribbling. He had consulted a urologist for this difficulty in the past and in the last year or two his symptoms had been increasing. On rectal examination his prostate was described as grade 2 plus to 3, benign in nature. His postoperative course after abdominoperineal resection was uneventful and a short trial after removal of his catheter revealed him to be voiding only in amounts of 1 or 2 ounces. The catheter was replaced after twelve hours and urograms obtained. These demonstrated a normal upper urinary tract. He was subjected to transurethral prostatectomy with removal of 45 gm. of tissue. Following this he voided easily and freely and his postoperative course was prolonged less than a week. He was allowed up and about with his catheter in place on the first postoperative day. The catheter was removed on the second postoperative day after transurethral prostatectomy.

The absence of prostatic obstruction, on the contrary, does not guarantee the absence of bladder neck obstruction, for the patient may have a markedly sclerotic bladder neck. This contracture of the bladder neck may be such as to give only minimal symptoms but in the presence of the altered detrusor force and disturbance of the anatomical plane of the bladder floor and trigone, becomes greatly magnified. We have been repeatedly impressed by the fact that even the removal of a few grams of tissue of an elevated posterior vesical lip will allow the patient to urinate. This fact has been repeatedly observed in patients having neurogenic bladders from other causes, such as spinal lesions. It would seem therefore, extremely important that after two or three trials with removal of the catheter, when the patient is ambulant, the cause of his urinary difficulty be determined.

Our practice is to have an excretion urogram made to determine the status of the upper urinary tract and aid us in estimating the renal function. Blood chemistry studies are obtained and the patient well hydrated by oral or parenteral fluids.

The general surgeon, as well as the urologist, has brought up the question of correction of the vesical neck obstruction preoperatively. We believe that postoperative correction of the obvious vesical neck obstruction is wiser because removal of the obstruction does not eliminate possible detrusor paralysis, and these patients would then have catheter drainage for long periods of time after the necessary manipulation of the urethra and bladder neck by resection. Also, the reaction following transurethral operation is much less after resection, owing no doubt to destruction of some of the blood supply to the

prostate gland and also to the walling off of the lymphatic drainage. The prostate undergoes regression in size so that it is much smaller at this time. Revision, accordingly, is done with greater ease and is carried out in periods averaging less than twenty minutes. The absence of any blood loss and any possible acute infection would seem to be a decided advantage in these patients. Also, it is possible to get these individuals out of bed in twenty four to forty eight hours after operation. We have operated on 54 patients with bladder neck obstruction without a death because of these factors. The question of carcinoma of the rectum, in our minds, takes precedence over prior transurethral



Fig. 298 (Case II) —Urogram showing dilatation of the upper urinary tract more marked on the left

operation for this reason. Oral medication with sulfadiazine and sulfathiazole and intravenous fluids help splint the upper urinary tract and it is surprising the small amount of reaction that these patients have. Many of them remain afebrile and the replacement of insignificant blood loss by transfusion is not necessary.

The use of routine urograms has disclosed that dilatation of the ureters occurs in some instances following Miles resection. The avoidance of injury to the ureter and isolation of it, from the general surgeon's viewpoint, is mandatory. We feel that it is a mistake, however, to strip them routinely from their beds and possibly both denervate and devascularize them. That this dilatation does not result from a



Fig 299 (Case II) —Urogram showing dilatation of the upper urinary tract, more marked on the left.



Fig 300 (Case II) —Urogram showing dilatation of the upper urinary tract, more marked on the left

long continued prostatic obstruction is borne out by the fact that we have observed it repeatedly in females and in males without prostatic enlargements. The lysis of the lower third of the ureters, we believe so interferes with the blood and nerve supply that prolonged infection of the urinary tract and damage to the upper urinary tract are inevitable results. The clinical course in the following case report would seem to exhibit some of the points under discussion.

CASE II—A 69 year old man underwent a two stage Lahey abdominopenneal resection for carcinoma of the rectum. He was maintained on tidal drainage using potassium permanganate solution as an irrigating agent. Urograms made at this time gave negative results. Cystoscopic examination was carried out and a very definite prostatic obstruction observed. This was corrected. The preliminary cystometric reading revealed a flat type of curve with all the components being displaced toward the right. Urograms made 1 month later disclosed bilateral hydronephrosis without gross abnormality of the bladder. Cystoscopic examination revealed relaxation of both ureteral orifices. Urograms (Figs 298 to 300) made three months later demonstrated progressive dilatation of the upper urinary tract, more marked on the left. The cystometrogram revealed the increase in intravesical pressure and the patient was able to empty his bladder up to several ounces.

Bladder atonicity from detrusor paralysis, because of the shortness of its appearance, does not portray on the cystogram any peculiar picture, such as the pyramid bladder, but rather various forms of operative distortion. However, no alteration may be seen in the outline of the bladder itself in an anteroposterior view. The protection of the upper urinary tract in patients having complete paralysis is of paramount importance. A profound, incurable pyelonephritis with possible formation of calculi and various degrees of pyelectasia and ureterectasia may result if the bladder is allowed to attempt to empty itself. The tidal drainage mechanism allows frequent automatic irrigation and the careful adjustment of this to the intravesical pressure will

be carried out in this group so that here again the recovering bladder will not have to compete with obstruction at the bladder neck. The use of a Foley bag using the 30 cc size bag which is large enough to prevent it from engaging in the posterior urethra seems indispensable and eliminates the messy adhesive strappings. We have given up the use of a small 5 cc Foley bag since it may become engaged in the urethra and produce spasm and incomplete drainage.

In patients having various degrees of atonicity of the bladder without obstruction, the indwelling catheter is removed most opportunely when these patients can sit up in a chair or are up and about and then can use their accessory urinary muscles, namely the diaphragm and the abdominal wall, to better advantage. Most of these patients incur damage to the upper urinary tract in the form of pyelonephritis at the

time of the removal of the catheter. Special attention to the intake and output record and, more particularly, to the amount of voiding, should be given. A patient voiding 2 or 3 ounces at a time may have what amounts to practically an overflow bladder and whatever recovery has been obtained from any detrusor paralysis or in an uncomplicated abdominoperineal resection may be lost when the usual order is left to catheterize the patient if he is uncomfortable. The bladder at this time not only has a loss of its motor components, as pictured by the cystometrogram, but shows a decided shift to the right in its sensory component, and the usual sensation to urinate is seriously depressed and is expressed only by a vague discomfort or abdominal pain. Such a bladder, so allowed to overdistend, will again revert to complete atonicity and this, coupled with an ascending urinary tract infection, will cause the entire clinical progress to collapse.

The progress of recovery from this type of bladder dysfunction can be gauged by the rise in intravesical pressure, bedside cystometrogram and the patient's own subjective information of the return of bladder sensibility. We believe that this form of treatment with the addition of urinary antiseptics will spare the patient's urinary system.

In lesions involving the prostate and posterior urethra, *perineal urethrostoma* may result. In the past year 2 such cases were encountered. At the time of operation it was noted that the urethra had been entered into with the necessary dissection and the catheter was then allowed to remain in place for a period of several weeks before changing. It is important to emphasize at this point that insertion of the catheter may be extremely difficult after an abdominoperineal resection with the possible altered anatomical course of the urethra, undue trauma with the production of fever from infection may result and seriously impair the patient's progress from repeated urethral catheter manipulation. Such perineal fistulas usually will close, their later repair will be simple and nursing care facilitated if indwelling catheters are permitted to remain for a period of three to four weeks. Here again it is of great aid to maintain these patients on a closed drainage system or automatic siphonage so that the bladder and upper urinary tract will be spared from infection.

Urethritis is at times a distressing symptom and the patient will complain bitterly when urethral drainage is still mandatory. The urethral catheter should never be larger than the external urinary meatus. This is the smallest part of the canal. A catheter which stretches the external urinary meatus will not allow the mucus about the catheter to escape and also a later sequela will be either a meatal or a navicular stricture. *Periurethritis* with abscess formation can result from prolonged drainage, and inspection for this may easily be made by running one's hands along the urethra and palpating the catheter over it. Unexplained fever with adequate urinary drainage is

frequently due to urethritis and absorption from the urethra is very much greater than from the bladder. In 1 patient we had to resort to perineal urethrostomy because of marked periurethritis.

Injuries to the ureters may be accidental or intentional. Involvement of the ureter by a growth may necessitate removal of a segment. This problem, to our mind, may be solved two ways. The immediate solution is to ligate the ureter with silk, which was done in one instance with the hope that the kidney may atrophy or, as in most instances, hydronephrosis will result, and the removal of this kidney can then be done at a later date when the immediate surgical crisis has been passed.

The second form of management is restoration of the ureteral continuity. This was done by one of our general surgeons in the following manner. A catheter was passed down into the bladder through the lower segment and then threaded into the upper segment and an end-to-end anastomosis made. The inlying ureteral catheter provided perfect drainage and the aim of the surgeon to bridge the immediate surgical crisis was obtained. Two weeks later the ureteral catheter was removed cystoscopically with no disturbance in the patient's post-operative course. Another method of handling this would be the use of a T-tube with the long arm of the T coming out through an opening above the point of union to avoid a stricture at this point. Drainage should be provided when anastomosis takes place. The T-tube serves this purpose adequately.

While every effort should be made to conserve a kidney whose ureter has been cut either intentionally or accidentally, the aim at this point should be a means to avoid nephrectomy at the time of the abdominoperineal resection. A study of the upper urinary tract can then be made postoperatively and, with the knowledge of a sound kidney on the uninjured side, nephrectomy can be performed some weeks later with more surgical impunity. This to our minds is the focal point of this surgical dilemma.

Some patients may have to be kept on small doses of urinary antiseptic following their discharge from the hospital for a long period of time and some may need permanent maintenance doses.

CONCLUSIONS

Urinary tract infections account for most of the complications after large bowel surgery. These patients may be subjectively free of urinary symptoms so that repeated examination of their urine is necessary during their postoperative course in and out of the hospital. The wise use of urinary antiseptics can avoid future trouble for them.

A careful assay of male patients with urinary symptoms prior to operation will help to avoid needless lengthening of their hospital stay because of marked urinary obstruction.

MANAGEMENT OF ANESTHESIA IN BOWEL SURGERY

LEO V. HAND

THE management of anesthesia for surgical procedures on the bowel must insure the maximal degree of safety for the patient. The duties of the anesthesiologist in his management of anesthesia include the responsibility for preoperative medication, the choice and administration of the anesthetic, the supervision of and responsibility for supportive therapy prior to and during the operation, and the treatment of certain postoperative complications.

PREOPERATIVE PREPARATION

Supportive Therapy.—The age, physical state of the patient, and the type and site of disease influence both the contemplated operative procedure and choice of anesthetic agent and method. Extremes of age are definite problems. In the management of anesthesia the first preoperative consideration is directed toward insuring supportive therapy to improve the patient's physical state for the contemplated operation. In acutely ill patients with early or impending shock and prostration, intravenous therapy is of particular value—fluids, blood, inorganic salt and protein replenishment. In chronically ill patients with debilitation, anemia and obstruction, the treatment is directed not only to replenishment but also preventive therapy. Replenishment therapy includes the administration of food, fluids, proteins, inorganic salt, blood and vitamins. Preventive measures include the administration of specific drugs such as sulfonamides, the use of the Levine tube for gastric drainage or lavage, and of the Miller-Abbott tube for intestinal drainage and decompression.

Premedication.—The primary preoperative consideration of the anesthesiologist is premedication. The purpose of premedication can be briefly divided into three general parts: (1) to provide for the comfort of the patient, that is psychic and physical; (2) to lower metabolic activity, thus facilitating administration of an anesthetic, and (3) to safeguard against untoward or unpleasant reactions that might occur during or after the operation to the detriment of the patient. The three general classes of premedicants employed are the derivatives of opium, of barbituric acid, and of belladonna. Basically, the opium derivatives act as direct metabolic depressants and enhance the effect of soporific drugs, thus lowering emotional excitement. The barbituric acid derivatives allay emotional excitement and afford protection from toxic effects of the usual agents employed in local and re-

gional anesthesia. The belladonna derivatives decrease secretions, act as metabolic stimulants to antagonize respiratory depressive effects of the opiate, and lessen the reflex response to cardiac vagal activity.

The more frequently employed combinations of these three classes for medication for good risk adult patients are as follows. When in halation anesthesia is to be employed morphine, $\frac{1}{6}$ grain, scopolamine, $\frac{1}{200}$ grain, and nembutal, $1\frac{1}{2}$ grains, are given. In regional anesthesia the following combinations are ordered for field blocking, a moderately heavy dose of pantopon, $\frac{1}{3}$ to $\frac{1}{2}$ grain, a very small dose of scopolamine, usually $\frac{1}{300}$ grain, and a relatively small dose of nembutal, usually $1\frac{1}{2}$ grains, for spinal anesthesia, pantopon, $\frac{1}{3}$ grain scopolamine, $\frac{1}{150}$ grain, and nembutal, 3 grains. The combination of opiate and belladonna derivatives is usually given subcutaneously one to one and a half hours preoperatively. Barbituric acid derivatives are usually given by mouth three quarters to one hour before operation. In the aged, debilitated and very poor risk patients, these doses are evaluated and reduced by the anesthetist making the preoperative visit. Over premedication may result in serious postoperative complications arising from respiratory depression. Too light premedication can usually be supplemented intravenously in the operating room. Thus, the average dose of preoperative medication may be summed up as light to moderate medication for general anesthesia and moderate to heavy medication for local or regional anesthesia.

OPERATIVE MANAGEMENT OF ANESTHESIA

Agent and Method.—The choice of agent and method of administration for anesthesia in bowel surgery are largely dependent upon (1) the age and physical state of the patient, (2) the type and site of disease, and (3) the extent of the contemplated surgical procedure. In bowel surgery very few procedures may be classified as minor procedures, requiring little or no surgical relaxation.

In infants and very young patients an inhalation anesthetic is employed, open drop ether is the agent and endotracheal intubation the method of choice. In very poor risk patients on whom the minimal degree of surgery is planned, the combination of an inhalation agent, cyclopropane, and an intravenous agent, such as curare, is administered. This combination has the decided advantage of having no direct depressive influence on the circulatory system. In the hands of a competent anesthesiologist, any complicating respiratory depression resulting from this combination may be treated by passive or controlled respiration.

Experience has demonstrated that subarachnoid block or spinal anesthesia with a light supplementary anesthetic, approaches more nearly the optimal anesthesia for bowel surgery. This combination in the hands of a competent anesthetist insures three favorable factors

(1) unvarying maximal relaxation of the abdominal muscles, (2) the quiet, regular action of the diaphragm which, together with (3) contraction of the intestine, produces the most favorable operating conditions of any method of anesthesia. The agent and method to be employed in spinal anesthesia depend on the contemplated procedure. For operations which probably will require less than one and a half hours of anesthesia, pontocaine³ with dextrose solution has proved highly satisfactory.

Usually bowel operations have a contemplated duration exceeding one and a half hours. For this operation the technic¹ of fractional (continuous) spinal anesthesia is routinely employed. Our agent of choice for fractional spinal anesthesia is pontocaine dextrose. Occasionally nupercaine,³ 1 to 1500 dilution by the single dose method, has been used in bowel surgery.

Supportive Therapy.—During all operations in which resection is contemplated, fluids and blood are readily administered by an intravenous drip equipment, with the needle placed in the great saphenous vein as it ascends in front of the tibial malleolus. This route also provides a means for rapid administration of a supplemental anesthesia—intravenous morphine, pentothal sodium or curare, supportive drugs, that is pressor drugs to combat serious falls in blood pressure, and corrective drugs, such as atropine, to stop or inhibit hiccups.

In instances in which use of the cautery is contemplated, the supplemental anesthetic of choice, nonexplosive in type, is an intravenous fractional dose of either morphine or pentothal sodium. Adequate oxygenation of the patient is always maintained. Occasionally, 50 to 70 per cent nitrous oxide plus oxygen is given in conjunction with pentothal. The use of nitrous oxide reduces appreciably the quantity of pentothal necessary to insure ideal supplemental anesthesia. When the cautery is not to be used or after its use, cyclopropane is frequently employed. Occasionally and in rare instances small doses of curare have been administered to reinforce a spinal anesthesia which apparently is wearing off. The use of supplemental anesthesia has a two fold advantage: (1) with an unconscious patient the surgeon is at liberty to discuss freely the disease encountered, and (2) with the usual extensive manipulations associated with this type of operation there is less of a clinical response to traction with its resulting reflex falls in blood pressure and associated cycles of nausea and retching in the conscious patient. Therefore, early employment of a supplemental anesthetic usually guards against increasing the mental and physical discomfort of the patient.

In spinal anesthesia, 50 mg. of ephedrine sulfate is given intramuscularly prior to introducing the spinal anesthetic agent. This acts as a prophylactic agent against the occasional fall in blood pressure that might occur following injection of a spinal anesthetic solution.

When moderate to marked falls in blood pressure occur pressor supportive drugs such as neosynephrine (3 minims) or pitressin ephedrine mixture (pitressin 5 units ephedrine 25 mg) have been employed routinely intramuscularly and in rare instances intravenously in greatly reduced quantities. In abdominoperineal resections under spinal anesthesia change from a supine to a lateral position frequently results in fall in blood pressure. In order to inhibit these falls in blood pressure a mixture of 5 units of pitressin and 25 mg of ephedrine is administered intramuscularly approximately fifteen to twenty minutes before the contemplated change in position.

POSTOPERATIVE MANAGEMENT

Medication—At the present time it is the opinion of most anesthesiologists that the use of opiates has been greatly abused in postoperative care in general and in bowel operations in particular. Postoperative medication may influence the convalescence. Too little results in unnecessary discomfort to the patient. Too much unnecessarily depresses the patient and predisposes to pulmonary complications such as atelectasis or abdominal complications such as ileus with resultant distention. Recent study has demonstrated that morphine prostigmine has decided advantages over morphine alone for postoperative pain relief. Conclusions on the value of morphine prostigmine are as follows: (1) the quantity of morphine necessary for pain relief after operation is approximately halved; (2) the time interval from subcutaneous injection to relief of pain is shortened appreciably; and (3) the duration of relief from pain is almost doubled.

An interesting clinical observation was made during the above study. The surgeons, nurses and patients commented on the early presence of gas pains. These were frequently manifested on the second postoperative day. This discomfort usually was relieved by insertion of a rectal tube. With morphine alone these pains as a rule do not appear until the third day, are vague and are accompanied by some degree of distention. In many instances opiates were being administered injudiciously for the relief of this prolonged discomfort. In rare instances morphine was employed to induce sleep. This decidedly is an abuse. Barbituric acid derivatives are far superior and considerably safer for this particular service.

Postoperative Complications—Of the many postoperative complications that may arise three are of special interest to the anesthesiologist: (1) pulmonary complications such as atelectasis; (2) intestinal complications as distention; and (3) vascular complications thrombophlebitis in particular.

Atelectasis usually occurs in one of three forms: massive or involving an entire lung; partial or involving one lobe; and patchy or lobular in nature involving many small areas within one or more

lung fields. Considerations in the prevention of atelectatic complications include frequent turning of the patient and urging him to cough up any accumulated fluids in the respiratory tree; cautious use of respiratory depressive drugs for the relief of pain or to produce sleep. The value of carbon dioxide as a preventive of complications is questioned.

When these conservative measures fail, immediate active measures should be instituted to remove the fluid. The simplest method is aspiration of the secretions in the trachea. A fairly large urethral catheter, 20 to 24 French, is passed into the larynx by means of a forceps under direct laryngoscopic vision. If atelectasis results from occlusion of an air passage, the most efficient and surest method of treatment is aspiration of the secretions in the respiratory passages by means of suction bronchoscopy. The best results are obtainable when the earliest signs of trouble are noted rather than waiting until it has fully developed.

2. *Intestinal distention.* In the past, 100 per cent oxygen was frequently employed for the relief of intestinal distention. At the present time the judicious use of the Miller-Abbott tube has more or less supplanted the administration of oxygen. The rationale for the employment of 100 per cent oxygen is that it reduces the nitrogen present in the intestinal tract by replacement with oxygen, an absorbable agent, because of the tendency of the body to bring about equilibrium of gases.

3. *Thrombophlebitis.* Venous intravascular clotting is always considered a special hazard in surgical procedures on the bowel when there has been considerable manipulation or if the operation is carried out in and around the iliac vessels.

The three general types of venous intravascular clotting are superficial thrombophlebitis, phlebothrombosis and femoro-iliac thrombophlebitis or "phlegmasia alba dolens." The clinical picture, prognosis and treatment of each type vary. Superficial thrombophlebitis is seen frequently in superficial varicose veins. Pulmonary emboli rarely follow thrombosis in a varix. Palliative treatment followed by saphenous ligation with retrograde and subsequent peripheral injections yields a high percentage of cures. Phlebothrombosis arises in the deep veins of the lower extremities. Clinical signs are usually vague until the pulmonary embolus ensues. Little to no inflammation is associated with this type of vascular clotting. It usually results in a loose clot, predisposing to ready dislodgment and resultant pulmonary embolus. In this type the best treatment is early ligation of the femoral vein distal to the profunda branch.

Femoro-iliac thrombophlebitis is the type of clotting thought to be the result of mechanical trauma to the endothelial lining of the vein, bacterial invasion or chemical injury. The clot is usually fixed and ad-

herent to the vessel wall. Clinically, the onset is usually sudden, with pain, leg edema, elevation of temperature or combinations of these symptoms. Pulmonary emboli rarely arise from this type of thrombosis. It is best treated by a combination of anticoagulant therapy and paravertebral sympathetic nerve block.⁴ In most instances, the best results with the paravertebral sympathetic nerve block are obtained during the acute stage of the complication. As a rule, daily blocks are employed until the patient's temperature returns to normal. The accompanying pain is usually relieved by the first or second block. The pyrexia and associated edema are usually relieved by the end of the third daily block. In instances of chronic thrombophlebitis, the results of paravertebral sympathetic block alone have not been encouraging. The results are usually transitory and the initial disturbances return on the resumption of normal activities. At the present time medical anticoagulant therapy plus paravertebral sympathetic nerve block is the method of choice in the treatment of acute femoro iliac thrombophlebitis complicating operations on the bowel.

SUMMARY

The duties of the anesthesiologist in the management of anesthesia for surgical procedures on the bowel have been outlined. Preoperatively, his primary interest is premedication. The amount and rationale for premedication have been summarized. The choice of agents and methods for anesthesia has been reviewed. Supportive measures enhancing anesthesia have been mentioned. Methods for the prevention or treatment of operative or postoperative complications have been reviewed.

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THE USE OF CURARE IN ANESTHESIA

URBAN H EVERSOLE

It is amazing that such a useful drug as curare should have remained clinically dormant so long. The existence of this drug has been known since the latter part of the sixteenth century. Apparently the first white man to observe the effects of the drug was Sir Walter Raleigh during his famous voyage up the Orinoco.¹ In the middle of the nineteenth century Claude Bernard experimented with this drug, confirming the observation that the paralysis it caused was due to interruption of the neuromuscular mechanism.² From this time until the last decade curare was used very little except in the physiology and pharmacology laboratory. In 1938, Richard C. Gill, an American who had lived for many years in the upper Amazonian jungles of Ecuador, brought back to the United States the first adequate supply of the drug the source of which was known, from which accurately assayed extracts could be made. Before this there was great variation in the pharmacologic and physiologic effects of various preparations of curare. Furthermore, there were numerous toxic side effects from this drug. This was due to the fact that there was no uniform source from which the drug could be obtained. A standardized preparation³ of curare is now available.

As established by Claude Bernard the effect of curare is essentially the interruption of nerve impulses at the myoneural junction. The action of curare at the myoneural junction is such that the muscle will respond neither to mechanical stimulation of the nerve nor to the injection of acetylcholine. Curare does not affect nerve conduction. Search for a clinical application for this drug dates back many years. As early as 1879 Hoffman administered the drug to control the seizure of tetany. Apparently he used doses that were too large, he reported severe respiratory depression for which he performed tracheotomy and artificial respiration. Except for an occasional mention of the drug being tried for tetany, we find very little in the clinical literature concerning curare until Burman administered it in 1938 for the treatment of muscle spasm and rigidity in spastic paralysis and dystonia musculorum deformans. In 1940 Bennett used this drug to prevent the traumatic complications which so frequently accompany convulsive shock therapy. He found that if the drug was administered

* This drug is standardized to contain 20 mg of curare per cubic centimeter and is marketed in 5 and 10 cc ampules under the name of intocostin by the E. R. Squibb Company.

plane of inhalation anesthesia or the administration of a large dose of an intravenous anesthetic such as pentothal. With the introduction of curare, what was once a most distressing occurrence during the course of an operation is now of minor importance. A single dose of curare will usually allow the operation to be terminated and the abdomen safely closed with the muscles well relaxed. Even when continuous (fractional) spinal anesthesia is employed, we have used curare to great advantage toward the end of operation when all that is necessary is a few minutes of relaxation so that the abdomen may be closed satisfactorily. This has served to decrease the total amount of spinal anesthetic agent used.

Patients undergoing *bronchoscopy* or *esophagoscopy* oftentimes require general anesthesia. Unless ether anesthesia is quite deep the relaxation may be inadequate for these procedures. Also, when pentothal sodium is employed, even with careful cocaineization of the pharynx, larynx and trachea, profound respiratory depression may ensue before the patient is sufficiently relaxed for the surgeon to carry out the procedure with facility. A combination of pentothal and curare has proved very satisfactory for these procedures. Knight recommends a ratio of 2 cc. of 2.5 per cent solution of pentothal to 1 cc. of curare for bronchoscopy and esophagoscopy. Our experience has been that it is necessary to increase the ratio of pentothal to curare to about 3 to 1 instead of 2 to 1. Usually 8 to 12 cc. of 2.5 per cent solution of pentothal combined with 3 or 4 cc. of curare is sufficient to render the patient unconscious and completely relaxed without serious depression of respiration. It is advisable to spray the throat and trachea carefully with cocaine before administration of these agents to avoid the laryngospasm which so frequently accompanies manipulation in the throat under pentothal anesthesia.

More recently we have combined curare with pentothal in doses sufficient to decrease the amplitude of respiration to aid the surgeon during the *resection of the upper thoracic portion of the sympathetic chain for hypertension*. These operations are performed under spinal anesthesia with only sufficient pentothal to render the patient unconscious. The addition of curare will decrease the amplitude of respirations during the resection of the upper thoracic portion of the chain. It is important to point out here that one must be very alert in the use of this technic as these cases are fraught with danger of respiratory difficulties which follow the inadvertent opening of the pleural cavity and, furthermore, should the initial dose of curare be sufficient to produce respiratory arrest, and it becomes necessary to institute artificial respiration, increased pressure incident to this maneuver would render the surgeon's work more difficult than if no attempt had been made to decrease the amplitude of respiration.

There is a very small group of patients which I hesitate to report.

I do so only in the hope that more experience can be obtained with them and that the results of the use of this drug may be better evaluated. During operations in the upper part of the abdomen, particularly on the stomach, hiccups sometimes are a most distressing complication. In a few instances in which it was impossible to stop the hiccups by the use of intravenous atropine and carbon dioxide, or with profound depth of anesthesia both with inhalation and intravenous agents, we have resorted to curare. In most instances the results have been most gratifying. Either the hiccups were stopped completely or they were rendered so feeble as to produce no disturbance to the operative field. Undoubtedly, to obtain this effect the dose must have been sufficient to have considerable diaphragmatic effect. In only one case out of six, however, was respiratory arrest complete. In all of these cases the amplitude of respiration was considerably decreased and oxygen was administered throughout the procedure.

As was stated before, practically the only dangerous complication with the judicious administration of this agent is respiratory depression or arrest. The fact that the muscles supplied by the cranial nerves are the first affected, followed by the skeletal and abdominal musculature and finally by the muscles of respiration has been established by many observers.^{5,7,9} It has also been well demonstrated that there is a definite antagonism between curare and prostigmine. This has been borne out on numerous occasions by clinical experience. Hence the pharmacologic antidote for curare poisoning is prostigmine. On the other hand, since the lethal dose with artificial respiration exceeds by many times the lethal dose without artificial respiration and the effect of this drug is so transitory, it would seem to be almost never necessary to use a drug as an antidote. The prime contraindication to the use of this drug is the absence of apparatus for establishing a free airway and maintenance of artificial respiration and personnel capable of carrying out these procedures.

Curare is now available in a standardized preparation. Techniques have been worked out for practical application of the effects of this drug as an adjuvant to other anesthetic agents in the production of abdominal relaxation. The drug is also useful in certain other procedures, such as bronchoscopy and esophagoscopy, and to supplement spinal anesthetics that have terminated before the operation is completed, and for certain procedures in which the work of the surgeon can be greatly facilitated by very quiet respirations.

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THE PREOPERATIVE AND POSTOPERATIVE USE OF SEDATIVES AND NARCOTICS IN THE AGED

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THE indiscriminate use of sedatives and narcotics in the aged is undesirable especially when one considers the types of operations which are likely to be performed. Among the more common major procedures encountered are prostatic operations, reducible or strangulated hernia, cancer, intestinal obstruction and arteriosclerotic gangrene of the extremities. Cholelithiasis and renal lithiasis are not uncommon. Fractures, especially of the femur, are often serious conditions.

In general, the lower level of liver and kidney functions which play such an important role in the breakdown and elimination of these drugs is responsible, in part at least, for the relatively poor tolerance to narcotics in the aged. Careful selection of a drug in proper dosage is desirable. The "rule of thumb" that children and the aged do not tolerate large dosage is to be respected.

Barbiturates comprise the largest group of sedatives and have the same general type of depressant action on the cerebrospinal system. In larger doses, these drugs act as hypnotics or soporifics. Usually the hypnotic dose is three to four times the sedative dose. The oral route is preferable, but intramuscular, intravenous or rectal administration may be necessary.

Barbiturates are readily absorbed from the gastrointestinal tract and are detoxified by the liver and excreted by the kidney. Short acting barbiturates, such as seconal and cvpal, are almost completely destroyed in the liver. Long acting drugs, such as phenobarbital and barbital, depend on the kidney for excretion. It is important, therefore, to know the functional capacity of these organs before barbiturates are given. Impairment of either organ may cause a cumulative toxic effect from the use of the drug.

Phenobarbital, which is a long acting drug, is largely excreted through the kidney but is detoxified in the liver. Barbital, on the other hand, is wholly excreted through the kidneys unchanged. These drugs should be used with caution in the debilitated and advanced arteriosclerotic patient. Symptoms of chronic poisoning are drowsiness, weakness, speech impairment, disorientation, confusion, skin eruption and abnormal neurologic signs.

Generally, phenobarbital in doses of $\frac{1}{4}$ to $\frac{1}{2}$ grain twice daily, is efficacious as a sedative. As a soporific, the dose may be increased to 1 grain at bedtime. Ipral calcium, a long acting barbiturate, is a good hypnotic in dosages of 2 grains. Amytal, an intermediate acting drug may be given in doses of 1 to $1\frac{1}{2}$ grains. Seconal, in doses of $\frac{1}{2}$ to

$\frac{1}{4}$ grain is brief in its action, produces almost immediate sleep and does not leave any mental cloudiness

The use of any barbiturate in hypnotic doses produces sleep within fifteen to sixty minutes. As a preanesthetic drug the dose ($1\frac{1}{2}$ grains) is greater than that for hypnosis and less than that for basal anesthesia.

Barbiturates are given in a 2.5 to 5 per cent solution for use intravenously, intramuscularly or subcutaneously. The intravenous route entails danger and should be used only in emergencies and for surgical procedures which require a brief acting anesthetic. They should be given very slowly. If evipal or pentothal is used a dosage of less than $7\frac{1}{2}$ grains is desirable. Overdosage may cause respiratory failure and circulatory collapse.

Paraldehyde, a central nervous system depressant, has a wide margin of safety and should be used more often. Its offensive odor should not prevent one from using the drug. It is believed that the liver plays a role in the detoxification of paraldehyde. Much is excreted through the lungs unchanged and very little is excreted through the kidneys; hence its advantage in renal disease. In chronic bronchopulmonary disease it may be irritating because of its excretion through the lungs. As a hypnotic it is given in a dose of 4 to 8 cc orally. The unpleasant taste may be masked with chilled orange juice. The drug produces sleep in about fifteen minutes. Respiration and circulation are not depressed in therapeutic dosage. Rectally it is given in 3 to 5 dram doses mixed with equal parts of olive oil and 1 cc of benzyl alcohol. The mixture alleviates rectal irritation. For intramuscular use 4 to 8 cc is given every four hours. It should not be combined with morphine because of its toxic effects.

Chloral hydrate, which is inexpensive and effective, is readily absorbed by the gastrointestinal tract and is detoxified in the liver and excreted by the kidney. It produces sound sleep. Used as a sedative or soporific it is given in a dosage of $\frac{3}{10}$ to 1 gm. Its unpleasant taste may be overcome by diluting it with milk, water or syrup of orange. The drug is contraindicated in severe liver, renal or cardiac disease.

Official U.S.P. preparations of *bromides* are potassium bromide, calcium bromide, sodium bromide and ammonium bromide. Combinations of sodium, potassium and ammonium salts may be useful for chronic sedation. The average dose is 1 to 2 gm twice daily. In the presence of dehydration, debilitation, prostatism and impaired renal function the preparation should be used with extreme caution because bromide intoxication can easily develop.

Morphine is the drug of choice for relieving pain. It is a depressant of the central nervous system. Its narcotic action produces analgesia and sleep. It is absorbed through parenteral and oral routes and approximately 90 per cent is slowly detoxified mainly by the liver. Ten

per cent is excreted in the urine within the first four hours. Very small amounts are eliminated in the feces.

Morphine should be given subcutaneously in small doses, $\frac{1}{8}$ to $\frac{1}{20}$ grain, every four hours for alleviation of discomfort. Atropine sulfate, grain $\frac{1}{200}$, may be combined with it to prevent undue depression of the respiratory center. Morphine should be used judiciously in patients who have debilitation, myxedema, anemia or pulmonary emphysema. Secondary effects from its action may be delayed for several hours to days. Larger doses cause mental confusion, respiratory depression, anorexia, vomiting and ileus.

Codeine sulfate is about one sixth as potent as morphine and is largely excreted in the urine. It may be given by mouth or subcutaneously in doses of $\frac{1}{4}$ to $\frac{1}{2}$ grain every four hours.

Dilaudid has the same margin of safety as morphine and can be given orally, subcutaneously or rectally. The dose ($\frac{1}{32}$ to $\frac{1}{64}$ grain) is one fourth to one fifth that of morphine and it has minimal hypnotic effect.

Pantopon has no advantage over morphine sulfate and is more expensive. It has not been definitely proved that it produces less side reactions than morphine. The dose is $\frac{1}{8}$ to $\frac{1}{12}$ grain by mouth or subcutaneously every four hours.

Demerol hydrochloride is a synthetic drug and chemically and pharmacologically it resembles morphine and atropine. Its analgesic, spasmolytic and hypnotic actions make it unique. Its analgesic effect is between that of morphine and codeine, and lasts for three to four hours. Liver or kidney disease does not affect tolerance for the drug. Demerol is excreted through the kidneys. It may be administered orally or intramuscularly—50 to 100 mg every three to four hours preoperatively and postoperatively. The drug is absorbed in fifteen to twenty minutes.

Demerol has a fairly good range of safety and it rarely depresses respiration. Untoward effects are dizziness, nausea and vomiting, weakness and syncope.

Tremor and convulsions may occur when doses are excessive and repeated often. Demerol is a good substitute for morphine, therefore, it should have wider use in the aged.

The use of sedatives and narcotics in the aged has been discussed. The importance of smaller dosages of drugs that are used is pointed out.

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out and stretched, and finally the fungating tumor mass makes its appearance. Radical removal, if they are seen early enough, may bring about excellent results. However, recurrences appear in about 70 per cent of the cases, with pulmonary metastasis. According to Gross, they vary greatly in size, cell content and form, and are often seen in combination with osteoma, chondroma and lipoma. The origin of mammary sarcoma has long been a much debated and controversial subject, inasmuch as the breast is composed of epithelium and connective tissue structures. It is generally believed that the majority of cases of sarcoma of the breast arise in, or from, long standing benign fibro adenoma. It is also true that the majority of sarcomas of the breast are either adenosarcomas or fibrosarcomas.

Bishop, in his very excellent article on sarcomas of the breast, reported that in addition to the adenosarcomas and fibrosarcomas he has encountered other types such as the neurogenic sarcoma, liposarcoma, osteosarcoma and chondrosarcoma, lymphosarcoma, myosarcoma, angiosarcoma, and even melanoma. Reports of neurogenic sarcoma are to be found in the literature, but their appearance is not hard to explain when one considers how richly endowed the breast is with nerve tissue from which these tumors can arise.

Bishop reported such a case of neurogenic sarcoma with a rather low grade of malignancy. The myosarcoma or leiomyosarcoma probably finds its origin from smooth muscle fibers in and about the ducts and vessels. The presence of liposarcoma can be traced to a proliferation of the young fat cells in the fat tissue of the breast or in a previously existing lipoma. The recording of lymphosarcoma and Hodgkin's disease usually calls for considerable questioning, inasmuch as lymph tissue is not found in the normal breast.⁴ When such is found it is most likely a part of a lymphosarcoma process arising elsewhere in the body. In evaluating the prognosis in a case of sarcoma of the breast, several factors should be taken into consideration. Metastasis in sarcoma occurs much later than it does in cases of carcinoma and many of the tumors fail to show metastasis of any kind. Their spread occurs chiefly by way of the blood stream. Axillary and supraclavicular nodes are seldom involved.

The relative infrequency of metastasis to axillary lymph nodes has frequently been recorded. Gross, in a report of 156 cases of various types of sarcoma, found the axillary lymph nodes involved in only 3 cases. A much higher proportion of invasion of the axillary nodes, however, is recorded by other writers. Secondary tumor implants are found in the lungs, liver, pancreas, bone and in other organs. None of our 8 patients upon whom radical mastectomy was done showed invasion of the axillary lymph nodes.

Local recurrences appear in a very high proportion and usually the recurring tumors are of a higher degree of malignancy than that of the original tumor.²

TABLE 1.—SUMMARY OF CASES

Case	Age, Yrs.	Duration of Detection	Location of Tumor	Operation	Microscopic diagnosis	Axillary Lymph Node Involvement	Result
1	40	3 yrs.	Left breast	Radical mastectomy	Adenofibrosarcoma	None	No recurrence after 5 yrs.
2	62	5 yrs.	Left breast	Simple mastectomy	Adenofibrosarcoma	None	No recurrence after 5 yrs.
3	59	1 yr.	Left breast	Radical mastectomy	Adenofibrosarcoma	None	No recurrence after 5 yrs.
4	69	3 days	Right breast	Radical mastectomy	Adenofibrosarcoma	None	No recurrence after 5 yrs.
5	51	5 mos	Right breast	Radical mastectomy	Adenofibrosarcoma	None	No recurrence after 5 yrs.
6	52	5 yrs	Left breast	Radical mastectomy	Liposarcoma with intracanalicular adenofibroma	None	No recurrence after 5 yrs.
7	48	Mole on left shoulder since birth; mass in left breast for 2 yrs	Left breast	Radical mastectomy	Melanotic sarcoma	None	Died 6 mos. later of extensive abdominal metastases
8*	50	1 yr.	Right breast	Radical mastectomy	Undifferentiated sarcoma	None	No recurrence after 5 yrs.
9	51	6 yrs	Right breast	Radical mastectomy	Adenofibrosarcoma	None	No recurrence after 2 yrs.

* Case 8 was the only male in the series

If the lesion is seen early, it can be completely removed, and yet many sarcomas may remain unchanged over a period of years. Many surgeons advocate simple mastectomy in early cases of sarcoma of the breast, but it is the policy at the Clinic, in view of the fact that axillary involvement does occasionally occur, to subject all patients to a radical surgical procedure. In following such a method the instances of recurrence may be greatly reduced, and the opportunity for permanent recovery greatly increased.

In this group of 9 cases the left breast was involved in 5, the right in 4. The side involved appears to have no significance.

Radical mastectomy was the operative procedure in 8 of the cases with simple mastectomy being used in the remaining one. Axillary glandular involvement was not observed in any of these patients upon whom radical mastectomy was done. The length of time the tumor had been present ranged from three days to six years. One patient, a woman aged 48, reported having had a pigmented mole on her left shoulder since birth, two years previous to coming to the Clinic the mole had been removed by electrocoagulation. The microscopic diagnoses on the cases reported were: adenofibrosarcoma, 6 cases, undifferentiated sarcoma, 1 case, liposarcoma with intracanalicular adenofibroma, 1 case, and melanotic sarcoma, 1 case (Table 1).

On follow up study of these cases five years after operation it was found that 7 of them had no evidence of local or general metastases. One patient who had had a melanotic sarcoma succumbed six months after operation from a generalized metastatic process. The ninth patient was operated on February 7, 1944, and to date has had no evidence of recurrence.

SUMMARY

Sarcoma of the breast occurs infrequently, and in a group of 1704 cases of malignant disease of the breast (pathologic material) was found only 9 times.

Most cases arise from benign adenofibromas of the breast and, therefore, all such tumors should be removed as early as they are noted upon examination in order to prevent sarcoma from developing.

A small group of 9 cases seen in a period of fourteen years is reported. Although invasion of axillary lymph nodes is infrequent, it does occur and radical mastectomy should be done with a thorough dissection of all axillary nodes.

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CARCINOMA OF THE BREAST: AN ANALYSIS OF 300 CASES

SAMUEL F MARSHALL AND NORMAN N FORNEY, JR.

CARCINOMA of the breast, like carcinoma of the female pelvic organs is one of the most common forms of malignant disease occurring in women. The U S Bureau of Statistics in 1942 reported 15,954 deaths from cancer of the breast and in 1943 the number very closely approximates that figure, there being 16,140 deaths (Table 1). These

TABLE 1—CARCINOMA OF BREAST—MORTALITY U S BUREAU OF VITAL STATISTICS

	No of Deaths	Rate per 100 000
1943	16 140	12 0
1942	15 954	11 9

<i>Sex Distribution</i> (1943)		No of Cases	Per Cent
Male		218	1 3
Female		14 908	98 04

figures include deaths from cancer of the breast in males and females. In 1943 there were 216 cases of carcinoma of the male breast, representing 1 3 per cent of the total (16,140) deaths. Carcinoma of the male breast, then, is not a common occurrence. There have been 1695 cases of carcinoma of the breast studied in the pathologic laboratory of the New England Deaconess Hospital, only 5 (0 3 per cent) of which occurred in the male breast. This group represents operated cases only (Table 2).

TABLE 2—MALIGNANT TUMORS OF BREAST—1704 CASES FROM THE
PATHOLOGY LABORATORY, NEW ENGLAND DEACONESS HOSPITAL

	No of Cases
Sarcoma	9
Cancer in male	5
Cancer in female	1687
Unrecorded	3

In a previous communication from this Clinic,² a group of 196 patients with cancer of the breast treated from 1926 to 1936 was analyzed and reported. We thought it would be of value to attempt a brief

analysis of 300 additional patients treated in the Clinic since that report. Sarcoma of the breast and patients who had had operation for cancer of the breast elsewhere before admission are not included in this group of 300 cases. This group represents a cross section of a somewhat larger group and consists of reports on those patients whose records were most complete. It does not represent a group of patients who were selected because of better results following operation.

This is a preliminary report to a later analysis in which these two groups of cases will be combined in an effort to obtain a more complete and accurate follow up record in all these cases and thus give a report on final results in this combined group of cases.

We were particularly interested in the survey of this group of 300 patients to consider the relationship of such factors as *age*, *heredity* and *fertility* to the occurrence of cancer of the breast. Furthermore it is of interest to analyze the symptoms and signs which brought the tumor to the attention of the patient and to give a brief analysis of our results of treatment.

As Boyd has pointed out, cancer of the breast is a disease of the *involuting breast*, occurring most frequently at and after the menopause. As reported by other observers and as was noted in our previous analysis of 196 cases, the largest numbers of patients with cancer of the breast in this series of 300 cases were in the fifth, sixth and seventh decades, as illustrated in Table 3, 271 patients, or 90 per cent, were 40 years of age or older.

TABLE 3 —AGE INCIDENCE IN 300 CASES OF CARCINOMA OF BREAST

Years	No of Cases	Per Cent
20-29	5	1.7
30-39	24	8.0
40-49	84	28.0
50-59	91	30.3
60-69	67	22.3
70-79	27	9.0
80 plus	2	.7
	<hr/> 300	<hr/> 100.0

Cancer of the breast occurs any time after the age of 20 and in rare instances it has been reported before the age of 20. In this group 5 cases occurred in women between 20 and 30 years of age. It is evident then that lesions of the breast in young women should be taken seriously until proved by pathologic examination not to be carcinoma.

Hereditary influence appears to be significant in various series of cases studied and reported. In this group of 300 cases, 60 patients or 20 per cent, had close relatives who had had cancer in some form. Of this group of 60 with hereditary history of cancer, 10 or 16.6 per cent

gave histories of breast cancer in the family. This appears to be a relatively high occurrence of cancer in the family (20 per cent) but is in agreement with the report of a review of 2636 cases of mammary cancer by Ian MacDonald who found 20 to 30 per cent of his group to have a family history of cancer.

The case histories of these 60 patients with family histories of cancer were studied carefully to determine whether their cancer background had any bearing on the end results of survival, recurrence, and so forth, but no significant conclusion could be drawn in this small series of cases.

From previous reports, hereditary influence appeared to exist in 5 to 10 per cent of cases studied from this approach to the problem, but Guleke, who proposed rather rigid criteria to classify these cases, reduced the hereditary factor to 2.36 per cent of the cases studied.

The history of *previous pregnancy* in relation to cancer of the breast appears to be without definite influence. In the group of 300 patients, 171 or 57 per cent had borne children, while 129 or 43 per cent had never been pregnant. As far as we were able to determine in this study, pregnancy had no relationship to the occurrence of cancer of the breast nor did it appear to affect the five year survival of these patients after operation.

The most important single factor influencing the successful treatment of cancer of the breast is *early diagnosis* of such lesions and the *early institution of treatment*. Unfortunately, the interval between the onset of symptoms and the discovery of a lump in the breast until operation was performed was frequently a considerable one. In this group of 300 patients coming to operation, the average time interval was 10.7 months. As noted so often with cancer arising in other regions of the body, pain or discomfort in the breast frequently drew the patient's attention to a lump in the breast, or at least this discomfort induced the patient to seek medical examination and advice. Too often, however, pain was evident only after advanced involvement of the breast or extension to the axillary nodes was noted. Too frequently the breast lump had been noted several months previously, but because it did not trouble the patient, she did not seek medical examination. Again, in some cases, a history had been secured of examination by a physician who assured the patient that it was "safe to watch it for a while." *One cannot emphasize too often that every tumor of the breast should be regarded seriously, regardless of the age of the patient, and that the lump should be removed and immediate pathologic examination made.* Only in this manner can we hope to obtain better end results in the treatment of mammary cancer.

The symptoms and signs which first attracted the attention of the patient to a breast tumor are tabulated in Table 4. As would be expected, the most common symptom was the finding of a mass in the

breast or tissue immediately adjacent to the breast tissue, occasionally the patient may note a tumor in the axilla, without any discomfort noted in the breast itself. In twenty four patients (8 per cent) the breast lesion was found on routine physical examination either at the Clinic or by the referring physician, illustrating the value to the patient of regular physical examination. Under the symptom of pain were included descriptions by the patient of discomfort, heaviness or sore feeling, these are also such common symptoms in the noncancerous breast that such complaints should always demand most careful examination of both breasts to rule out cancer. This complaint probably accounts for recording in the history of such a high number of patients (107 or 35.7 per cent) who noted some type of pain.

TABLE 4—SYMPTOMS AND SIGNS IN 300 CASES OF CARCINOMA OF BREAST

	No of Cases	Per Cent
Lump in breast	260	86.6
Pain in breast or adjacent tissue	107	35.7
Axillary mass	102	34.0
Retraction of nipple	59	19.3
Discharge from nipple	22	7.3
Ulcer on breast	17	5.7
Edema of arm	8	2.7
Itching of breast	3	1.0

In all patients admitted to the Clinic with a diagnosis of cancer of the breast or tentative diagnosis of carcinoma of the breast routine roentgenologic examination of the chest is obtained. A routine roentgenogram of the bony skeleton is not obtained unless symptoms suggest the possibility of bony metastases. Careful abdominal and pelvic examinations should also be made to rule out liver metastases and implantation of secondary tumor in the pelvis. Unless definite evidence of metastatic malignant disease can be demonstrated other than to the axillary nodes, a radical mastectomy is performed on most patients. If there is a fixed mass in the axilla, metastases to the lungs or bony skeleton, radical mastectomy is contraindicated. Roentgen therapy offers the only method of controlling the growth.

In the Clinic, a *biopsy specimen* is obtained in all cases of tumor of the breast and immediate pathologic examination made of a frozen section. Should the tumor prove to be malignant, radical mastectomy is immediately performed. This includes removal of the pectorals major and minor muscles, together with thorough dissection of the axillary region. It makes little difference what type of incision is employed and frequently the type of incision has to be varied and adopted to the position and extent of the lesion. We most often employ the simple incision encircling the breast, with vertical extension above

and below the breast. This incision permits adequate exposure and ready dissection of the axilla without extension of the skin incision into the axilla or onto the arm. This latter type of incision so often limits arm motion. The transverse incision is also very useful and can be employed with advantage in certain cases.

In no case was roentgenologic therapy employed preoperatively. It is, however, employed almost routinely in all cases postoperatively, except in elderly patients over the age of 65 who usually are not treated with roentgen therapy after operation.

Roentgen therapy is instituted at the time of the patient's first visit to the Clinic for postoperative dressing, ordinarily ten to fourteen days after operation. A discussion of roentgen therapy postoperatively in cancer of the breast is given elsewhere in this volume by Dr. Hugh F. Hare.

TABLE 5—TYPE OF OPERATION IN 300 CASES OF CARCINOMA OF BREAST

	No of Cases	Per Cent
Radical mastectomy	272	88.8
Simple mastectomy	34	11.2
Total breast operations in 300 patients	306	100.0

Table 5 shows that 272 breasts were removed by *radical mastectomy* and 34 by *simple mastectomy*, making a total of 306 breast operations in 300 patients, 6 patients having had both breasts removed. Simple mastectomy was performed either because of the age and general condition of the patient or as a palliative operation because the extension of the disease was such that it was felt that a radical procedure would be of no avail. We wish to call attention again to the 163 patients in whom lymph nodes were involved. We gave the percentage of patients with node involvement as 54.3 per cent of the total patients, although actually the percentage should be still higher since, of course, no axillary nodes could be recorded for the simple resections. If we, therefore, correct this figure on that basis, it shows that in 59.9 per cent of the patients who had radical mastectomy the axillary lymph nodes were involved.

In this group of 300 patients submitted to operation, there were no operative deaths. Operation was performed on 153 patients over five years ago and 64 or 41.8 per cent, are alive and well. In the group of 64 patients surviving over five years, 21 or 42.8 per cent, had involvement of the axillary lymph nodes. In the previous report⁴ of 196 patients, 38.6 per cent survived over five years. This five year survival figure includes the tumors with and without axillary node involvement. This approximates the five year survival rate reported from other clinics, as follows: Grenough and Simmons (Huntington Hos-

pital), 32 per cent Sistrunk and McCarty (Mayo Clinic), 36 per cent, and Lee (Memorial Hospital), 39 per cent. We believe that when we obtain a more accurate follow up of the two combined groups the figure of 41.8 per cent may show some improvement in the total five year survivals. When we further analyze the entire series the 19 cases reported in 1938 and this present report of 300 cases the five year survival is approximately 65 to 70 per cent of those in whom there was no metastasis to lymph nodes whereas only approximately 18 to 20 per cent with lymph node involvement can be expected to survive five years.

TABLE 6—PATHOLOGIC FINDINGS IN 300 CASES OF CARCINOMA OF BREAST
(306 BREAST OPERATIONS)

	Breasts	Per Cent
Carcinoma simplex	235	76.9
Adenocarcinoma	49	16.1
Intraductal carcinoma	5	1.6
Metastatic carcinoma	3	0.9
Epidermoid carcinoma	1	0.3
Chronic cystic mastitis with early carcinomatous change	1	0.3
Carcinoma type not stated	12	3.9
	<u>306</u>	<u>100.0</u>

Table 6 gives the type of pathologic change noted in this series of 300 cases. Boyd divided malignant tumors of the breast in general, into two pathologic types. He stated that the carcinoma may be a spheroidal cell in origin arising from epithelium of the acini and is a *carcinoma simplex* or it may arise from the epithelium of the ducts and is an *adenocarcinoma*. He stated that the proportion of epithelial tissue to connective tissue may vary considerably and this gives rise to various types of carcinoma listed as scirrhous, medullary and so forth. Colloid degeneration may occur in any form resulting in colloid carcinoma. It will be noted that carcinoma simplex is by far the most common type. This is true in this group of 300 cases.

In the group of 1695 cases from the pathologic laboratory of the New England Deaconess Hospital approximately 80 per cent were carcinoma simplex.

SUMMARY

An additional group of 300 operated cases of mammary cancer since the last report in 1938 is reported with a five year survival rate of 41.8 per cent following radical operation. Unfortunately the diagnosis of carcinoma of the breast was established too late in the disease in the majority of the cases to improve materially the survival rate.

Radical operation in this type of malignancy can be done with mini-

mum risk as illustrated by no fatalities resulting after operation in a series of 300 cases. Radical operation should be done earlier, is a safe procedure and it is hoped if done early enough before involvement of lymph nodes occurs, that it offers a reasonably high percentage of good results.

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RADIATION TREATMENT OF CARCINOMA OF THE BREAST

HUGH F HARE

RADIATION treatment of carcinoma of the breast is used at the Lahey Clinic either as a prophylactic measure following surgical removal of the breast or as a palliative measure in the inoperable or recurrent cases. It has not been used as a method of cure without previous operation nor has it been used as a preoperative measure in an attempt to sterilize the malignant tumor.

There has been adequate therapeutic trial of the sterilization of the tumor bed by radiation and a more thorough attempt at sterilization of secondary nodular metastases as well as bone metastases. Sterilization has rarely been noted even following intensive radiation. It is important, therefore, that we, as radiologists, use radiation for palliative purposes only and that we do not harm the patient by giving larger amounts of x rays than the normal tissues can tolerate.

With this in mind and with the advent of the shock proof apparatus, a plan of treatment was devised in 1934 for the *postoperative treatment* of cancer of the breast to be used regardless of the severity of the disease or the grade of the malignancy. The treatment is started as soon as the patient becomes ambulatory and the healing of the surgical wound permits. In order to evaluate treatment, a routine method wherein the treatment was given in the same way for each case was developed for prophylactic treatment.

The breast axilla and supraclavicular space on the side involved were all treated using three separate portals. The tissues to be treated by this method were adequately covered with a 15 cm round cone anteriorly and a 10 cm cone laterally, and each portal was treated daily until 2400 r measured in air, was delivered, using the following factors: 200 k v p, 1 mm of copper and 1 mm of aluminum filtration, distance 50 cm, giving each anterior portal 100 r units daily and the lateral 150 r. As much care as was practical was taken not to treat the lung fields with the full quantity of radiation.

The value of radiation treatment cannot be given in terms of five year survival without evidence of disease. Many patients who might have died during the first and second year after operation lived a comfortable and useful life and were free of visible cancer for a longer period of time as the result of the radiation treatment. This is indicated by the many patients who have not received routine postoperative radiation treatment for cancer and who have developed early secondary changes of malignancy.

Radiation treatment for *secondary malignant disease* was given for local recurrence in the breast area, for nodular disease in the axilla or supraclavicular regions, but no attempt was made to treat pulmonary metastases unless there was an associated intractable cough as a result of involvement of mediastinal nodes. Liver and abdominal metastases were not amenable to palliation.

The quantity of radiation to be administered and the method of applying it depend upon the site. If the lesion is a local recurrent one in the scar and limited to the skin, an attempt should be made to eradicate it by giving superficial radiation to the skin. A local recurrence may be adequately controlled by giving 3000 r, measured in air, in two divided doses of 1500 r each or by giving 2400 r, administered at one application. If the lesion measures more than 2 by 2 cm in size, the divided dose method is the most efficacious, as the degree of skin reaction is less and yet the end result is approximately the same. It is necessary and important to include at least 1 cm of normal surrounding tissue so as to include the surrounding lymphatics since the lesion may spread by way of these lymphatics.

Bone metastases from carcinoma of the breast are frequently seen. They are brought to our attention because of pain, and it is necessary that these patients be treated for palliation. Usually 1500 r delivered in divided doses will successfully relieve the pain of these lesions. Bone metastases are osteolytic in the menstruating woman and may be osteolytic or osteoblastic after the menopause. Following treatment of osteolytic bone lesions it is not uncommon to see them become osteoblastic in type and remain so for the remainder of the patient's life. When they do become osteoblastic they tend to remain asymptomatic for months or even years, so that it is advisable to follow each case with osteolytic metastases treated by radiation to determine the course of the disease in the bone.

It is at the time of metastatic bone disease that the patient needs and is entitled to the best of mental and moral care. To tell them that their case is hopeless does not help them, to tell them the truth with reservations has kept many people going and indeed happy. We plan to discuss the condition of the patient with the family before instituting therapy so that some responsible party is cognizant of the situation. It is up to the family members how much is told the patient because after all they are the ones who have to live with and care for these people twenty-four hours a day.

Radiation castration has been most useful in some cases but should not be used as a routine measure for patients who have not yet passed through the menopause. For a few years this method was tried with out any striking results as far as preventing recurrence of malignant disease was concerned but in several cases the psychic shock of the abrupt menopause in addition to the loss of the breast and the almost

certain knowledge of the patients that they had cancer was too much for them. These patients despite all attempts at prevention developed neuroses which were indeed difficult to handle. We believe that radiation castration should be used in certain well defined instances and when so used it is a remarkable palliative measure. It should be used only in recurrent cases. These patients should have pain in their metastatic lesions which is more severe before and during the menstrual period if radiation is to be successful. We have not seen any patient helped who did not have aggravation of pain at the time of the menstrual period and therefore this is a good sign to follow. It is advisable to explain to the patient at the time the radiation castration is contemplated that symptomatic relief if it is to be obtained, will not take place for at least sixty days because the menstrual periods are not controlled immediately by radiation treatment.

The value of routine postoperative radiation treatment of carcinoma of the breast has been subject to question by numerous workers. It may be that in the future this type of treatment may not be necessary or may prove to be unsound. With the present knowledge of malignancy however it does not seem advisable to discontinue it. We are now summarizing our results for a ten year period and it is upon these results that we shall decide the advisability or inadvisability of continuing routine postoperative treatment. Regardless of this decision, radiation treatment is a valuable palliative procedure for inoperable and recurrent malignant disease. It is not a cure.

Radiation castration is a valuable adjunct to the treatment of metastatic malignant disease of the breast in a small well defined group of cases.

THE SURGICAL ASPECTS OF OBSTRUCTING LESIONS OF THE ESOPHAGUS

HERBERT D. ADAMS

THE majority of obstructing lesions of the esophagus are now amenable to surgical treatment or eradication. With improvement and standardization of technic and especially with specific measures to control the very hazardous infection associated with esophageal surgery, there has been a corresponding improvement in results. Penicillin and sulfonamide have changed transpleural and mediastinal esophageal surgery from a very dangerous procedure to one of relative safety. As a result, the technical problems of these procedures have been clarified and an increasing experience in this field obtained. A general review of the more common surgical conditions of the esophagus and their present surgical status is therefore presented.

Since most of the important surgical diseases of the esophagus are obstructing in nature to some degree or other, there is a common symptomatology of varying grades and combinations of dysphagia, regurgitation and substernal pain and distress. These symptoms are of great significance since they frequently are due to such important clinical diseases of the esophagus as esophagitis, cardiospasm, diverticulum and carcinoma.

Chronic esophagitis probably occurs in a higher incidence than the numbers actually diagnosed would suggest. Those with vague substernal distress and symptoms are overlooked and only those cases with an appreciable degree of dysphagia and regurgitation are diagnosed by proper roentgenologic studies and esophagoscopy. The findings are dilatation, acute and chronic changes in the mucosa, varying degrees of ulceration, hypertrophy and fibrosis of the wall, with and without stenosis, and cardiospasm. Some of the more severe cases may have no true stenosis causing obstruction but the symptoms of dysphagia and regurgitation may be caused by an almost complete loss of function of the involved sections of the esophagus (Fig. 302).

In those cases with *true stenosis* and associated stricture, the esophagus must be very carefully and gradually dilated. In those patients whose general nutrition is badly impaired, a preliminary simple gastrostomy should be performed in conjunction with careful dietary management. Likewise, those patients with marked esophagitis who do not respond to these more conservative measures, and after an adequate but limited trial on dietary and chemotherapy regimen, should have their esophagus put temporarily at rest by gastrostomy.

Carcinoma must be ruled out by repeated examinations by esoph-



Fig 302—Esophagitis with obstruction showing the characteristic clear-cut, funnel like narrowing as compared with the irregular filling defect of carcinoma (see Fig 308)



Fig 303—Esophagus of a patient with long standing cardiospasm

agoscopy and numerous biopsies, as well as biopsies of lymph nodes from the vicinity of the cardia if the abdomen is opened for a gastrotomy. The pathologic report of chronic inflammation is not always reliable since biopsy specimens from deeper or other involved tissues may show malignancy. A rare case of severe and long-standing esophagitis without malignant degeneration may not respond to the conservative measures of dietary management, dilatations, and gas-

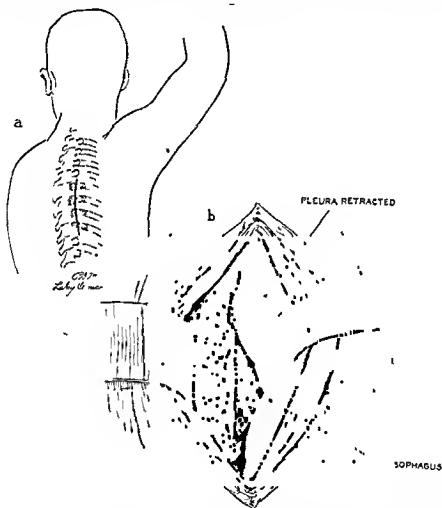


Fig 304.—Posterior mediastinotomy. Surgical approach for drainage of mediastinitis following manipulations of the esophagus

trostomy, and will require transpleural resection, using the technic described for carcinoma of the esophagus at the various levels.

Closely allied to this condition are the *strictures* due to ingestion of caustics, due to trauma and to cardiospasm (Fig. 303). All of these lesions have an associated varying degree of esophagitis which must be treated as well. Extremely careful, graduated dilatations must be done. Both the diagnostic esophagoscopy and the subsequent dilata-

tions and manipulations are often fraught with serious danger. If during these procedures, or immediately thereafter, the patient complains of sudden severe pain in the back, substernal or subcostal region, which persists and is accompanied by an immediate marked systemic reaction, a mediastinitis has been produced. The mortality will be 100 per cent unless immediate and drastic measures are taken to control it. Massive doses of penicillin, that is, a continuous drip of 100 000 units per liter of normal saline or 5 per cent glucose solution are started at once, and a dosage of 50 000 units is given intramuscularly every two hours, in addition. Drainage of the mediastinum by pos-



Fig. 305—Large pulsion type diverticulum of the esophagus

terior mediastinotomy should also be performed as soon as possible. This is done through a right paravertebral incision resecting the proximal portions and heads of the sixth, seventh and eighth ribs and corresponding transverse processes, carefully remaining extra-pleural by retracting the pleura from the bodies of the vertebrae and draining the mediastinum (Fig. 304). Even in a few hours the fascial planes of the mediastinum will be greatly distended with thin pus. Early and effective drainage of this type plus massive doses of penicillin will save these patients and they have little chance without it.

The remaining common, benign lesions of the esophagus which produce obstructive symptoms are the *diverticula*. The pulsion type existing in the upper esophagus, is much more common and usually eventually reaches a size producing obstructive symptoms. The de-

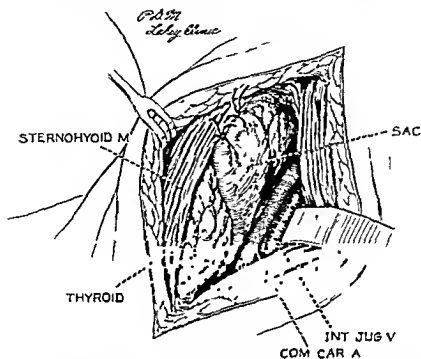


Fig 306—First stage resection of pulsion esophageal diverticulum



Fig 307—Large traction diverticulum

pendent sac reaches a size and weight when filled with food sufficient to angulate the esophagus at the neck of the diverticulum so that

the lumen of the esophagus immediately below that point is completely obstructed. Figure 305 is a roentgenogram of a pulsion diverticulum.

The pulsion diverticula are best operated on by a two-stage procedure, the first stage freeing and elevating the sac, which overcomes the esophageal obstruction, allows free drainage of the sac and sealing off of the fascial planes into the mediastinum. At the second stage the actual resection of the sac is carried out (Fig. 306).



Fig. 308—Filling defect of a carcinoma of the middle third of the esophagus. Compare with Figure 303.

The traction type of diverticulum is usually found in the mid-thoracic esophagus and rarely reaches a size sufficient to cause these obstructive symptoms (Fig. 307). The rare traction type that produces obstruction can be resected by an extrapleural posterior mediastinotomy approach or even by a transpleural approach, with heavy penicillin therapy in conjunction with it.

Perhaps the most common obstructing lesion of the esophagus is carcinoma. Increasing difficulty in swallowing food is the outstanding symptom and should always be investigated thoroughly by roent-

genograms (Fig. 308), esophagoscopy and biopsy. Cure by surgical resection can be accomplished in early cases. The close anatomical proximity of many other vital structures to which there is an early direct extension will, however, preclude resection and, in addition, the rich lymphatic bed in this region is conducive to rapid and early lymphatic spread which also makes resectability relatively low. This makes it even more essential that the earliest symptoms be investi-

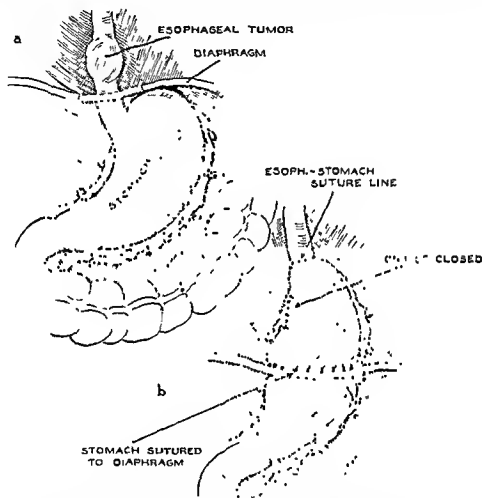


Fig. 309.—Resection through the left thorax for carcinoma of the lower two-thirds of the esophagus. *a*, Mobilization of esophageal tumor and stomach; *b*, method of anastomosis.

gated adequately. Improved technic and penicillin have lowered the operative mortality to a very satisfactory level.

The surgical approach to carcinoma of the esophagus necessitates that these lesions be divided roughly into those involving the lower half and upper half of this structure. In those involving the lower half, a left transpleural exposure is done. If the lesion is resectable, intestinal continuity is established by bringing the stomach up through

the diaphragm and anastomosing the stump of the esophagus to the top of the fundus of the stomach (Fig 309) This is a very satisfactory operation and has given good results

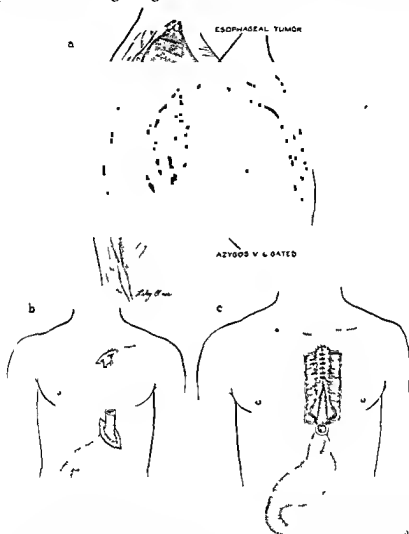


Fig 310—Resection through the right thorax for carcinoma of the upper third of the esophagus *a*, Exposure of esophagus by ligation and section of azygos major vein *b*, Antethoracic esophageal meatuses—the upper stoma established at the stage of resection the lower stoma established at a later stage *c*, Construction of an antethoracic skin tube connecting the upper and lower esophageal stomas

The management of carcinomas of the upper half of the esophagus is less satisfactory because of the impossibility of reestablishing directly the continuity of the gastrointestinal tract. For the same reason there is still considerable variation in the approach and staging of this surgical procedure. It is my opinion that the plastic tubular type of

gastrostomy (Janeway and Beck-Jianu) should not be used as a preliminary stage since it is too much of a surgical undertaking for these debilitated patients, coming even before the difficult and long transthoracic resection stage is done. In addition and equally as important, this type of gastrostomy does not produce a good functioning stomach or a nonleaking stom^a, and does not lend itself well to subsequent antethoracic artificial tubes and especially skin tubes. I prefer to do a simple catheter gastrostomy under local or spinal anesthesia, carefully examining and taking a biopsy specimen of the cardiosubdiaphragmatic nodes for abdominal metastases. If these nodes are negative, two to three weeks after the preliminary simple gastrostomy and after improvement in nutrition and the general condition, a second stage is carried out.

The second stage (Fig. 310) consists of a right transthoracic resection, ligating and sectioning the azygos major vein, resecting the involved esophagus, turning in carefully the lower stump and bringing out the upper end in the cervical region as the upper stoma. The patient is then sent home for a number of months, continuing on his gastrostomy feedings, and may swallow liquids by inserting a tube in his upper esophageal stoma and connecting it with his gastrostomy tube. When he has regained normal weight and health and if the lesion was favorable at resection, the patient returns to the hospital and the abdomen is reopened, the simple gastrostomy is closed, the stump of the esophagus mobilized from below through the esophageal hiatus in the diaphragm, cutting some of the vasa brevia but preserving the left gastric artery, and bringing the stump of the esophagus up into the wound to form the lower esophageal meatus. By this procedure a good functioning stomach is maintained, a nonleaking stoma is produced, with an esophageal stoma above and a similar esophageal stoma below. These lend themselves well to management either by the intermittent use of an artificial large tube or later to an antethoracic plastic skin tube.

SUMMARY

As a group, the obstructing lesions of the esophagus have the common symptomatology of dysphagia, regurgitation and substernal discomfort. All patients with these symptoms should have early, adequate study, including careful roentgenologic examinations, esophagoscopy and biopsy when indicated. Careful, staged, surgical treatment in conjunction with adequate penicillin therapy will cure many of these patients.

DIAPHRAGMATIC HERNIA

A Clinical Report of 34 Surgically Treated Cases

RALPH ADAMS AND WILLIAM F. LEE, JR.

PARE, in 1579, reported a case in which the patient had a penetrating wound of the chest and died of an obscure abdominal disorder. Autopsy revealed a laceration of the diaphragm with herniation of abdominal viscera into the thorax. In 1798 Cooper wrote a monograph on hernia and reported several cases of diaphragmatic hernia.

Some degree of herniation of abdominal viscera through the diaphragm now is known to occur in about 2 per cent of all patients examined roentgenologically⁷ for gastrointestinal complaints. The incidence of this condition has increased apparently during the past fifteen or twenty years. Rendich, in 1924, reported an incidence of 0.04 per cent in a series of 5033 cases examined, this percentage being consistent with others at this time. However, Levy and Duggan in 1941, reported an incidence of 2.1 per cent in 1220 cases examined. This trend has been reported by others^{4 10 11 12 13 14 15} in reviewing larger series of roentgenologic examinations of the gastrointestinal tract, and has been in accord with the findings at the Lahey Clinic. Prior to 1940 8 patients were operated upon for diaphragmatic hernia (a period of fourteen years). From 1940 through 1944, 26 patients were treated surgically. Harrington,⁶ at the Mayo Clinic, reported the same apparent increase in this condition. Probably this apparent increase in incidence has been brought about by the development of roentgenologic methods of diagnosis. Thus, diaphragmatic hernia has become recognized as an entity of frequent enough occurrence to warrant consideration when one is faced with the problem of treating a patient with gastrointestinal symptoms. It is with that fact in mind that this review of the subject is being written and a summary of 34 cases presented.

ANATOMY

The diaphragm in man consists primarily of the septum transversum which in the embryo stretches from ventral and lateral body walls to the ventral wall of the foregut. On either side of the foregut there is left a pleuroperitoneal canal, through which the pericardial and pleuroperitoneal cavities communicate. These canals are closed during development by the pleuropericardial membrane cephalad and by the pleuroperitoneal membrane caudad. Thus, the peritoneal, pleural and pericardial cavities are segregated. Growth of the liver is very

rapid and this organ carries some derivatives from the body wall to augment the diaphragmatic structure. The origin of the striated muscle of the diaphragm is not definitely settled. The classical theory as described by Bardeen in Arey's "Developmental Anatomy" is that the muscle originates from a pair of premuscle masses lying opposite the fifth cervical segment in the 9 mm. embryo—the level at which the phrenic nerve enters the septum transversum. These muscles follow the descent of the septum. Bremer, however, suggested that the muscular parts are formed by the burrowing of the expanding pleural cavities into the body wall so that the inner layer of muscle and fascia is stripped off and this layer then forms the peripheral part of the diaphragm. It is apparent that this structure with its complicated derivation embryologically will be most subject to anomalous changes resulting in actual hernias or weaknesses through which hernias may develop.

In considering the different types of diaphragmatic hernia, an embryonic defect¹¹ can be postulated for nearly all types except the traumatic (Table 1). The most common type in adults, the esophageal

TABLE 1.—TYPE OF HERNIA

	Number	Per Cent
Esophageal hiatus	22	64.7
Foramen of Bochdalek	5	14.7
Traumatic hernia	4	11.8
Foramen of Morgagni	3	8.8
Total	34	100.0

hiatus hernia, is developed in an enlarged opening through the diaphragm about the esophagus, as a result of the failure of the last step in the closure of the pleural passage. This closure is effected by the growth of a thin strip of liver and septal extension to join the mediastinum. Herniation through the pleuroperitoneal membrane or foramen of Bochdalek is prone to develop in case of failure or weakness of union between the septum transversum and the pleuroperitoneal membrane. This defect usually runs from the centrum radially toward the body wall, depending upon the extent to which the edge to edge union of the structures may fail to occur or break down. Herniation through the parasternal orifice, or foramen of Morgagni, occurs less frequently. Here the weak point is the interval between the tendinous fibers from the ensiform cartilage and the cartilage of the adjoining ribs. If the insertion into the seventh rib is deficient, this hernia may become quite large.

Traumatic hernia occurs either from direct or indirect trauma to the diaphragm. Direct injury by a penetrating missile or tissue destruction by infection and abscess may create a defect through which abdominal

viscera are able to pass Indirect injury occurs in crushing blows on the abdomen thus increasing pressure in the abdomen and sometimes forces viscera through the diaphragm

PATHOLOGY

The principal pathologic finding in diaphragmatic hernia is the displacement of abdominal organs from the abdomen into the thorax This may be extensive as in one case (J J R) in which the liver transverse colon omentum and small bowel were found to be within the thorax or may include only a portion of the omentum as occurred in another case (M P) in which omental tissue protruded through the foramen of Morgagni

Secondary phenomena may occur such as chronic peptic ulcer of the esophagus particularly in the case of a hiatus hernia with a congenitally short esophagus Söhler and Hampton reported a series of 221 cases of hiatus hernia of which 32 cases had either marked anemia or a positive history of bleeding from the gastrointestinal tract, suggesting gastritis or ulceration of the herniated fundus of the stomach Three cases in this series of 34 had a history of hematemesis All of these were hiatus hernias with the fundus of the stomach above the diaphragm but in none of them was an ulcer demonstrated It has been noted by many observers that duodenal ulcer cholelithiasis and other disorders may occur coincidentally with diaphragmatic hernia It is of great importance to bear these possibilities in mind at the operating table Also even though actually the cause of the patient's complaint the symptoms of the hernia not infrequently simulate those of gallbladder disease duodenal ulcer or gastritis

It is likely that some factor other than a congenital weakness is necessary to produce a diaphragmatic hernia First to be considered is the presence of a marked difference in pressure between the abdomen and thorax This becomes obvious in the case of traumatic hernia following abdominal injury or diaphragmatic hernia during pregnancy as reported by Rigler and Eneboe In the latter group the authors reported disappearance of the hernia on postpartum examination in a large percentage of the cases

It is believed that the elasticity of muscle tissue about the esophageal hiatus decreases with advancing age (Table 2) If true such relaxation would explain why diaphragmatic hernias are found most commonly in patients in the fifth and sixth decades of life The tension exerted by a congenitally short esophagus¹⁴ may account for the elevation of the stomach through the hiatus in this type of hernia It should be remembered however that a preoperative diagnosis of a short esophagus is rarely confirmed by the operative findings Tension is exerted also by adhesions between abdominal viscera and a hernia sac Thus omentum may become adherent to a hernia sac in

the diaphragm and gradually more and more omentum becomes pulled into the defect, to be followed by the colon and other viscera

TABLE 2 —AGE OF OCCURRENCE

Decade, years	Number	Per Cent
20-29	3	8.8
30-39	3	8.8
40-49	12	35.3
50-59	10	29.4
60-69	6	17.7
Total	34	100.0

Average age 48.5 years

Mean age 49 years

In nearly all cases there is probably a combination of congenital defect plus the aforementioned factors to produce diaphragmatic hernia

SYMPTOMS AND DIAGNOSIS

The variety of symptoms associated with diaphragmatic hernia at times presents a complex problem in differential diagnosis. In general, however, the symptoms are caused either by interference with the functions of the organs in the hernia or of organs displaced by the hernia. Inasmuch as some hollow viscus is nearly always involved in the hernia, obstruction of that viscus may occur, either partially or completely. Thus, in the case of the hiatus hernia involving the fundus of the stomach, the patient regurgitates food or has pain after eating. Increasing and obstinate constipation may occur in hernias involving the colon.

Interference with the functions of organs displaced by the hernia does not occur commonly except in large hernias displacing a large amount of lung tissue or the heart. The congenital hernias described by Ladd and Gross illustrate the extreme degree of pulmonary compression in infants in whom the presenting symptom is cyanosis, caused primarily by usurpation of thoracic space by abdominal viscera. In the 4 cases of traumatic diaphragmatic hernia reported here, dyspnea was a prominent symptom because of the large size of the hernia and consequent embarrassment of pulmonary function. Unless the possibility of diaphragmatic hernia is borne in mind, many cases will receive an incorrect diagnosis because of the possible variations and nonspecific symptoms. This type of hernia is a great masquerader and often simulates coronary disease, cholelithiasis, peptic ulcer³ and lung tumor.

In this series of cases the most common complaint was pain in the epigastrium or lower chest (Table 3). The pain usually followed the

TABLE 3—SYMPTOMS

	Number	Per Cent
Pain in epigastrium or lower chest	23	67.6
Dyspnea	5	14.7
Hematemesis	3	8.8
Constipation	2	5.9
Regurgitation of food	1	3.0
Total	34	100.0

ingestion of food or occurred during meals. In a few cases vomiting relieved the pain. Recumbency was reported as a pain aggravating factor in only 1 case. Dyspnea was the second most prominent symptom. Into this group fall the 4 traumatic hernias in the series as well as 1 patient with a large omental hernia through the foramen of Bochdalek. All of these patients complained of chest pain as well as dyspnea. Of the 3 patients presenting a history of hematemesis 1 vomited blood only once, three days before admission, while another had had repeated hematemesis during the six months prior to admission. Constipation was reported in only 2 cases. One patient was unable to swallow solid food. In nearly all cases the patient complained of "indigestion." This was described as a full feeling, sour taste, belching or heart burn.

As can be seen from the foregoing discussion, there is no one diagnostic symptom associated with diaphragmatic hernia. The diagnosis should not be made without roentgenologic examination of the gastrointestinal tract. Properly done, this examination will reveal a large percentage of the hernia defects present. In the series reported here the diagnosis was accurately made preoperatively by roentgenologic examination in 32 cases or 94.2 per cent. In the remaining 2 cases the hernias preoperatively were thought to be pulmonary lesions because they appeared to lie in the lower lung fields and only omentum was contained in the hernia. No barium was seen to enter the hernia on careful examination and consequently the diagnosis of diaphragmatic hernia was not made.

TABLE 4—CONTENT OF HERNIA

	Number	Per Cent
Stomach alone or stomach and omentum	18	52.9
Stomach and colon with or without omentum	9	26.5
Colon and omentum alone	3	8.8
Omentum alone	2	5.9
Stomach, colon, small bowel and omentum	1	3.0
Liver, colon, small bowel and omentum	1	3.0
Total	34	100.0

The physical examination is of very little assistance in the diagnosis of most diaphragmatic hernias. In those in which the thorax contains

a large abdominal viscus, the physical signs of dullness, absent breath sounds, or inspiratory borborygmi may be elicited over the chest. These findings are more common in infants with congenital lack of the left diaphragm and in cases of traumatic hernias with extensive diaphragmatic injury.

The use of the esophagoscope as a diagnostic aid has been advocated by Guthrie and Jones, especially in the presence of gastrointestinal bleeding. It has not been employed in the study of this series of cases.

TREATMENT

Only the surgical treatment of diaphragmatic hernia is under discussion in this paper. It must be borne in mind, however, that there are vast numbers of patients with definite roentgenologic evidence of diaphragmatic hernia who are relieved of their symptoms by conservative measures alone.⁸ Levy and Duggan reported such a series of cases treated medically, with good results. Surgical treatment is necessary if the hernia is causing bleeding, with anemia or symptoms which incapacitate the patient (Truesdale).

In the surgical repair of the diaphragm two technical principles merit emphasis. First, in reducing the hernia, all attachments between the abdominal viscera and the hernia sac should be divided. If there is no sac, the adhesions between viscera and pleura must be released. Second in repair of the diaphragmatic defect, simple closure with interrupted nonabsorbable sutures in two layers usually is adequate. In large defects such as occur with traumatic herniation, it may be necessary to use muscle or fascia flaps, as described by Rives and Baker. There were no cases in the series reported here in which this was felt to be necessary.

Interruption of the phrenic nerve to relieve symptoms related to diaphragmatic hernia has been used by many surgeons. Its use is limited to palliation in those cases in which surgical repair of the diaphragm is contraindicated. Harrington⁶ reported 18 cases in which phrenic interruption was done therapeutically. Over half of these patients later required a further surgical procedure for relief. Personal experience with phrenic interruption for this purpose has been limited. One patient in the series of 34 had phrenic interruption alone, with complete relief of symptoms for at least one and a half years. In 1 other patient the phrenic nerve was crushed with the hope that further operation would be unnecessary. However, she obtained no relief and after two weeks the diaphragmatic defect was repaired. In 2 other patients crushing of the phrenic nerve was used in conjunction with repair of the diaphragm.

The choice between a transperitoneal or a transpleural approach for repairing diaphragmatic defects is largely a matter of personal preference by the surgeon. In all cases of traumatic or recurrent di-

aphragmatic hernia the transpleural approach is recommended to facilitate the reduction of the hernia and the release of the numerous dense adhesions usually found in these cases, as illustrated by a case (J J R) of traumatic hernia with a large tear in the right diaphragm. The liver, transverse colon, small bowel and omentum were in the right hemithorax. An abdominal incision was made and it was found to be impossible to reduce the hernia without injury to the pleura or lung itself. Through a transpleural incision the reduction was readily accomplished. The incision in 6 cases was transpleural, in 26 cases transperitoneal, in 1 case combined, and in 1 case a phrenic interruption only was done.

The preparation for operation of the patient with diaphragmatic hernia requires only the usual measures taken for any other elective abdominal operation, with one exception. Many patients with diaphragmatic hernia are obese. It is necessary, therefore, for these patients to lose enough weight so that exposure of the diaphragm is made feasible. In occasional cases this is accomplished by the condition itself. The patients have pain after eating, develop a food fear and present themselves for treatment after having lost an appreciable amount of weight. The treatment of anemia, malnutrition, or other associated conditions is obviously of importance.

In the postoperative period pulmonary complications must be carefully watched for and treated, if they develop. The intrapleural air should be aspirated at completion of the operation to prevent mediastinal shift and respiratory embarrassment. Associated with trauma to the diaphragm or lung, pulmonary atelectasis may occur, with retained mucus and poor aeration. Bronchial aspiration is the most efficient method for relief of postoperative atelectasis. Occasionally aspiration and lavage of the stomach are necessary for relief of distention.

Subsequently, pleural effusion may develop and it should be removed with an aspirating needle. In 1 case an empyema developed postoperatively. The empyema healed promptly after drainage, and the patient has since been well.

RESULTS

The results in the series of 34 cases are depicted in Table 5. One patient died suddenly of a pulmonary embolus on the fourteenth postoperative day. Of the 5 patients living with roentgenologic evidence of recurrence, 1 has required resection of a duodenal ulcer, and she is now symptom free. Another patient now has roentgenologic evidence of a hernia, 2 by 4 cm., but is relieved of symptoms. Thus in the group of 30 patients on whom there is a postoperative follow-up record of at least six months in duration, 25 have been relieved of

TABLE 5 —RESULTS

	No of Cases	Per Cent
Well without symptoms or x ray evidence of hernia for 6 mos or more	24	70.6
Living with x ray evidence of recurrence	5	14.7
No recurrence but persistent symptoms	0	0.0
Hospital deaths (pulmonary embolus, 14 days)	1	3.0
Later deaths	0	0.0
No follow up	4	11.7
Total	34	100.0

PATIENTS WELL WITHOUT SYMPTOMS OR X-RAY EVIDENCE OF RECURRENCE

Length of Time following Operation	Number	Per Cent
6 months	4	11.7
1 to 2 years	8	23.5
2 to 3 years	4	11.7
3 to 4 years	3	8.8
Over 4 years	5	14.7
Total	24	70.4

symptoms and hernia, 2 are symptom free with recurrent hernia, and 3 were not relieved of symptoms

SUMMARY

A short summary of the embryology and anatomy of the diaphragm is presented which shows the complex origin of that structure. Because of this complexity, diaphragmatic hernia is not uncommonly found through areas imperfectly closed during fetal development. The pathology is discussed, with some suggestions as to causation of the hernia. A review of 34 surgically treated cases of diaphragmatic hernia is reported, with comments upon the symptomatology, diagnosis and treatment of this disorder.

CONCLUSIONS

- 1 Diaphragmatic hernia occurs in about 2 per cent of all patients examined roentgenologically for gastrointestinal disease.
- 2 The most frequent site of diaphragmatic hernia in adults is the esophageal hiatus—64.7 per cent in this series.
- 3 Diaphragmatic hernia is most often demonstrated in obese patients in the fifth and sixth decades of life.
- 4 The organs most often contained in diaphragmatic hernia are stomach and colon.
- 5 Symptoms are related to the organs involved in the hernia or to organs which have been displaced by the hernia.
- 6 Surgical repair of the diaphragm may be effected transpleurally or transperitoneally. The transpleural route is preferred in recurrent or traumatic hernias.

7 In 34 cases treated surgically the mortality was 3 per cent

8 Diaphragmatic hernia often is the explanation of gastrointestinal symptoms and a diagnosis may be made by careful roentgenologic study in nearly all cases

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THE PROBLEMS OF GASTROJEJUNAL ULCER WITH ILLUSTRATIVE CASE REPORTS

SAMUEL F. MARSHALL

GASTROJEJUNAL ulcer occurs so frequently that it seems worth while to consider some of the factors associated in its production and especially to consider those measures from the standpoint of the surgical procedure employed which might aid in the prevention of such recurrent ulcers. That recurrent ulcer is a frequent occurrence is exemplified by the fact that 69 cases of recurrent ulcer occurring after some type of gastric operation were met with in a series of 289 consecutive cases in which resection was performed for ulcer in the Lahey Clinic over a period of five years, 1941 to 1945 inclusive. In other words, approximately 1 in 4 patients requiring operation for peptic ulcer over a five-year period had had some form of operation for peptic ulcer which resulted in failure, that is, the production of recurrent ulcer. It is only fair to state that in 5 instances in these 69 cases of gastrojejunal ulcer the initial operation was done in the Clinic. It is evident from these figures that the problem of gastrojejunal ulcer is a considerable one and every effort should be made to employ such an operation in the treatment of peptic ulcer and in particular of duodenal ulcer which would effectually prevent such a serious complication.

From the outset it must be conceded that gastrojejunal ulcer will occur in a limited number of cases, no matter what type of operation may be employed, but it should be our endeavor to keep such a recurrence rate at a minimum. Reports from various writers with considerable experience in this field very clearly indicate some factor which contributes to the development of gastrojejunal ulcer and only recently (1945) Lewisohn⁵ emphasized the importance of adequate and well planned resection of the stomach for duodenal ulcer.

From an analysis of this group of 69 gastrojejunal ulcers it is apparent that three types of operation were possibly involved or contributed to the production of gastrojejunal ulcer. These were as follows: gastroenterostomy, the Finsterer operation, allowing the ulcer to remain *in situ*, and finally, an inadequate partial resection of the stomach. In this series of 69 cases there were 8 gastrojejunocolic fistulas which, of course, resulted from perforation into the colon of a gastrojejunal ulcer, the most serious complication of ulcer encountered. All these fistulas occurred after gastroenterostomy. There were 4 cases in which fistula followed the Finsterer exclusion operation and in 5 other

cases it occurred after a very inadequate gastric resection. In the remaining 60 cases fistula occurred at varying periods after gastroenterostomy. In a previous communication from this Clinic, the literature on gastrojejunal ulcer has been reviewed³ at length; the factors involved from an etiologic standpoint have been discussed fully.

Our purpose in this paper is to discuss the problem from the standpoint of the effect of any of the three operations listed previously in producing ulcer and to cite some illustrative examples.

Gastroenterostomy has been employed with decreasing frequency in the Lahey Clinic as a routine method of surgical treatment of peptic ulcer. It is our custom to apply the operation of partial resection with few exceptions to cases of peptic ulcer in which operation is required. In 1925 Lewisohn⁴ in a careful follow up study of his patients after gastroenterostomy found gastrojejunal ulcer in 34 per cent of cases; 18 per cent were definitely proved at operation. This rate is very high and probably represents the extreme, yet is illustrative of the very considerable danger of recurrent ulcer after gastroenterostomy. That there were 60 cases in which operation was required following gastroenterostomy in a five year period is at least reasonable evidence of the too frequent occurrence of this complication. Gastroenterostomy is a valuable procedure; it is true, in a few carefully chosen cases but in our experience it is almost certain to result in recurrent ulcer in young individuals or even in older patients with high acids or with an active ulcer present at the time of operation. It would therefore be wise to restrict its use to those cases in which there is marked scar tissue obstruction of the pylorus; in other words the end result of active ulcer with accompanying low acid values, or to those cases in which it is expedient and necessary from the standpoint of high risk involved to do a less radical procedure.

CASE I—A man aged 57 came to the Clinic January 24, 1940. He had ulcer distress for a period of twenty years. Posterior gastroenterostomy was done for an obstructing duodenal ulcer in October 1943. Following this operation his course was uneventful. He gained weight, was relieved of distress and worked hard for two years. In November 1945 he had a massive hemorrhage and required three transfusions to replace blood loss. This was followed by a return of old ulcer distress and pain unrelieved by antacids. Whereas prior to hemorrhage roentgen examination of the stomach showed satisfactory emptying through the gastroenterostomy stoma, following this hemorrhage he had 30 per cent retention of barium in the six hour examination.

Physical examination revealed that the patient was short, heavy and stocky with moderately heavy abdominal panniculus. The blood pressure was 130 mm. systolic and 70 mm. diastolic. Hemoglobin was 117 gm. Red blood cells numbered 4,200,000. Acid of 92.

gastrojejunal ulcer in an active duodenal perforated with the

of the ulcer consisting of edematous and inflamed tissue from the mesentery of

small bowel over the superior mesenteric vessels. A radical partial resection of the stomach was carried out, removing the duodenal ulcer and jejunal ulcer areas. It was necessary to resect the segment of jejunum involved, and jejunal continuity was restored by end to-end anastomosis. The patient made an uneventful recovery and left the hospital sixteen days after operation.

Comment—This case illustrates the occurrence of gastrojejunal ulceration following posterior gastroenterostomy. Ordinarily, this operation would be considered quite satisfactory in a man past middle age, with high degree of obstruction and, with the technical difficulties present at the time of the first operation, was probably justifi-

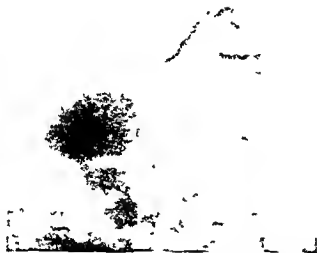


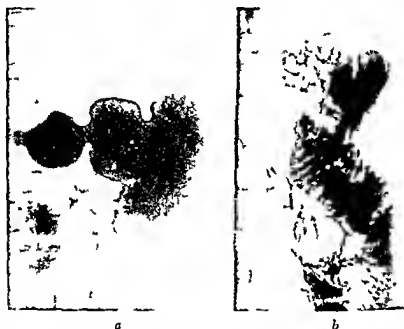
Fig 311 (Case I)—A gastroenterostomy is shown. About 2 inches distal to the stoma in the distal loop there is a definite crater on the superior aspect of the loop. This crater measures 1 cm. in diameter and is about the same depth. The jejunal loop is quite irritable. The duodenal cap is not visualized.

fied. It illustrates, however, the great danger of employing gastroenterostomy at any age in the presence of an active ulcer which is accompanied by high gastric acid values.

Gastrojejunal ulcer may occur at any age after gastroenterostomy, but it is especially likely to occur in young individuals (before the age of 40). If operation is found to be necessary to relieve ulcer distress in this younger group of patients gastric resection should always be done, otherwise the danger of recurrent jejunal ulcer is too considerable.

It has become increasingly evident from our own experience in the Lahey Clinic that an adequate partial resection of the stomach has

become a logical and practical surgical therapeutic measure for the treatment of complicated duodenal or gastric ulcer, and that extensive partial resection offers the best opportunity for permanent relief of ulcer distress should conservative medical measures fail to relieve and surgery be considered necessary. It is this type of operation that is most commonly employed in the surgical treatment of ulcer. The mortality accompanying gastric resection has materially lessened during the last five to ten years and should not be greater than that



a

b

Fig 312—Before and after resection for ulcer. Note that extensive removal of the stomach has been carried out.

a. The stomach has not been resected but a previous gastroenterostomy can be seen. There is obstruction in the jejunum beyond the gastroenterostomy, due to a jejunal ulcer.

b. Stomach after resection. A small gastric stump may be seen with normal emptying into jejunum.

accompanying gastroenterostomy. In a series of 570 consecutive partial resections to January 1946 at the Lahey Clinic there have been 10 deaths, an operative mortality of 1.77 per cent.

Usually, two thirds to three fourths of the stomach is resected (Fig 312) in order to remove a considerable portion of the acid secreting mucosa. We hope with this procedure not only to remove the ulcer area but in particular to reduce greatly the hyperacidity observed before operation. We aim by this operation to obtain a relative anacidity and thus reduce greatly the risk of recurrent ulcer. Haberer very

arly demonstrated that, to obtain permanent relief of symptoms of peptic ulcer, it was necessary to remove at least one-half of the stomach

This fact has been emphasized many times by surgeons with considerable experience in partial resection for ulcer

Pylorotomy and antrumectomy, as suggested by Bland Sutton, although an improvement over gastroenterostomy in the treatment of ulcer, removes an insufficient amount of the stomach and does not reduce materially the gastric hyperacidity following operation. As a consequence, it is an insufficient resection

Lorenz and Schur demonstrated conclusively that extensive resection of the stomach was necessary in order to obtain any marked reduction in hyperacidity accompanying peptic ulcer

Therefore, failure to remove a major portion of the stomach when partial gastrectomy is employed for peptic ulcer results in failure to reduce the gastric acidity materially, and a high percentage of recurrent ulcers will be found. The following case reports illustrate the complications arising after inadequate partial resection of the stomach and serve to emphasize the need for extensive resection of the stomach when operation is deemed necessary for relief of ulcer distress

CASE II—A man aged 40 was first seen in the Clinic on October 8 1942. Ulcer symptoms began in 1932 when he had an acute perforation of a duodenal ulcer. Evidently the surgical procedure consisted only of closure of the perforation. Early in 1939 typical ulcer distress developed and gastric resection was performed soon afterward (1939). Evidently he was relieved until November 1940 two years before admission to the Clinic. Pain recurred which at first was relieved by food and alkali but finally became so severe that morphia was required.

On examination the patient was found to be somewhat undernourished. He weighed 133 pounds. There were scars of two previous laparotomy incisions on the upper abdomen. Abdominal examination suggested a mass in the epigastrium which was extremely tender. Hemoglobin was 89 per cent, red blood cells numbered 5,300,000 and white blood cells 9700. Gastric analysis showed free acid of 24 and total acids of 30. Roentgenologic examination demonstrated that apparently he had a pylorotomy with gastroduodenal continuity restored. There was a constant defect at the duodenal juncture with the stomach (Fig. 313).

Operation was performed October 20 1942. The upper abdomen was filled with adhesions. The first part of the duodenum and distal portion of the stomach were markedly thickened and indurated. Evidently a Billroth I type of resection had been performed with only a small part of the distal portion of the stomach removed. A large ulcer was present on the lesser curvature of the stomach at the junction with the duodenum with deep penetration into the pancreas. Radical partial gastrectomy was carried out. Recovery was uneventful and the patient was discharged sixteen days after operation.

Comment—The Billroth I type of resection limits considerably the extent of the resection inasmuch as it is necessary to anastomose the duodenum which in the presence of ulcer is difficult to mobilize to the gastric stump and to leave a major portion of stomach unremoved.



Fig 313 (Case II) —Inadequate partial resection is shown. Previous resection had been performed three years before the patient was admitted to the Clinic. Very little of the stomach has been resected. The gastroduodenal continuity has been restored by a Billroth I operation. There is a constant defect present in the duodenum at the juncture of the duodenum and stomach.

in order to accomplish the restoration of gastroduodenal continuity without tension on the anastomosis.

It was obvious that a very inadequate resection had been done in this case and it was not surprising that ulcer recurrence took place. A sufficiently high resection relieved this patient of all his distress.

CASE III—A man, aged 36 years, came to the Clinic July 6, 1942. He had first noticed symptoms of ulcer two years before this admission. The distress was characteristic and at first was relieved by food and alkalis. Because of the persistence of the distress, operation was advised and resection of the stomach was done elsewhere in January 1942. In April pain recurred and obstructive symptoms developed. A second operation was advised and apparently a posterior gastroenterostomy was superimposed upon the previous stomach resection, which resulted in no relief of symptoms. On admission to the Clinic, he had severe epigastric pain and had lost 55 pounds in weight.

On examination the patient was pale and had obviously lost weight. Two laparotomy scars were noted in the upper part of the abdomen. Marked tenderness was noted in the epigastrium. The hemoglobin was 50 per cent, red blood cells numbered 3,650,000 and white blood cells 9000. Gastric analysis showed free hydrochloric acid of 30. A roentgenogram of the stomach demonstrated that pylorotomy had been done and that very little barium passed through the pyloric anastomosis (Fig 314). Just proximal to this anastomosis there was a large crater, extending onto the lesser curvature. A gastroenterostomy also was noted on

the greater curvature of the stomach with a persistent pocketing of barium in the jejunum. A diagnosis was made of recurrent gastric and jejunal ulcers.

At operation July 20, 1942, the diagnosis was substantiated and an extensive resection was carried out. The patient made an uneventful recovery and was discharged from the hospital sixteen days after operation.

At a follow-up examination January 21, 1943, the patient was quite well, was free of symptoms and had gained weight.



Fig. 314 (Case III).—Insufficient partial resection of stomach. Note that very little of the stomach has been removed at previous operation. Very little barium has passed through the pyloric anastomosis. Note the gastroenterostomy on the greater curvature of the stomach where there is persistent pocketing of barium in the jejunum opposite the stomal orifice into the stomach.

Comment.—Permanent relief of ulcer distress and the prevention of gastrojejunal ulcer is more often insured by a radical resection than by pylorotomy or by removal of only a small portion of the stomach. Reoperation will be necessary in the majority of these cases of inadequate resection and furthermore the resultant failure is blamed on the method when rather it should be attributed to a poorly executed and eventually insufficient resection. It has been our experience that extensive partial resection of the stomach has been followed infrequently by gastrojejunal ulcer and that the operation can be done with a very low mortality 1.77 per cent. Certainly our failures with resection have occurred after an insufficiently high resection in most cases. What the actual recurrence rate is after partial gastrectomy we are not yet able to state accurately as our group of cases is still in the process of being carefully studied postoperatively and no data on

this subject are as yet available. In our considered opinion that the rate probably will be around 3 per cent. We have had no recurrent ulcer following resection for gastric ulcer. Reports of follow up results after partial resection, in general, are excellent and recurrent ulcer is much less frequent than after gastroenterostomy. Mage has reviewed 502 cases of gastric resection for duodenal ulcer at Mt Sinai Hospital and reported that gastrojejunal ulcer was found at reoperation in 25 per cent and based on clinical evidence only 5.5 per cent. This is in marked contrast to 18 per cent found at reoperation and 34 per cent on clinical evidence, which was found in the same institution after gastroenterostomy, and reported by Lewisohn.

A method of resection of the stomach that has proved most likely to be followed by gastrojejunal ulcer is the prepyloric Finsterer type of resection. In this operation the ulcer is allowed to remain *in situ* and the transection is carried above the ulcer, with the safe closure of the duodenal end, usually necessitating that a portion of the pyloric end of the stomach be left in order to obtain an adequate length for turn in of the duodenal stump. This operation should not be employed in the presence of a high degree of obstruction occurring at the level of the ulcer, as the inverted stump would be blown open by the accumulation of secretion proximal to the ulcer. There has been considerable tendency in densely adherent ulcers or in ulcers deeply penetrating the pancreas to allow the ulcer to remain in order to avoid injury to the common bile duct. This type of operation may be employed occasionally in ulcers very low in the duodenum provided the line of transection above the ulcer is through the duodenum and beyond the pylorus. None of the pylorus with its mucosa should be allowed to remain and there should be enough of the duodenal tube left to provide for safe closure of the duodenal stump. If the transection permits part of the pyloric antrum to remain, the mucosa of the antrum must be removed then or this pyloric portion of the stomach must be removed at a later second stage.

For several years we have not found it necessary to employ the Finsterer operation save on a very rare occasion. With an increasing experience with partial resection practically all duodenal ulcers may be removed and an adequate closure of the duodenum be obtained. Exposure of the common bile duct and the determining of its relationship to the duodenal ulcer will aid materially in a difficult dissection. This should always be done with indurated and low lying duodenal ulcers and moreover it is our custom routinely to visualize the common bile duct in all resections. A choledochostomy may be done and a T tube with a long limb may be passed through the ampulla of Vater into the duodenum, thus permitting the surgeon to visualize or locate the common bile duct and its opening into the duodenum and prevent injury to the common bile duct or its duodenal opening.

There has been a high incidence of gastrojejunal ulcer occurring after resection of the stomach in which the pyloric area has been allowed to remain above an unremoved ulcer. This has not only been our own experience but this fact has been reported in the literature repeatedly. In this group of 69 recurrent ulcers there were 4 such cases. Haberer very early reported such a gastrojejunal ulcer occurring after the Finsterer operation in which the recurrent ulcer healed after removal of the retained pylorus. We have had 3 such patients with gastrojejunal ulcer in whom ulcer healing occurred with relief



Fig 315 (Case IV) —Duodenal ulcer prior to resection. The duodenal cap is grossly irregular, showing a pseudopenetration on its lesser curvature side.

of ulcer distress after removal of only the pyloric area. One patient (Case V) had had two resections without relief; the pyloric portion was later removed at a third operation followed by relief of ulcer distress. A large gastrojejunal ulcer noted at reoperation was not disturbed and later was proved to have healed following simple removal of the retained pyloric portion of the stomach.

CASE IV.—A man, aged 38, was first seen in the Clinic April 10, 1939. He had a typical history of ulcer distress for a period of fifteen years. Previous roentgenologic examination had shown a duodenal defect. Pain prior to admission was severe and was not relieved by diet and medication with alkalis.

On examination, the patient weighed 152 pounds. There were no significant findings save tenderness in the epigastrium. The hemoglobin was 13.6 gm; red blood cells numbered 4,990,000. Free hydrochloric acid was 10 and total 26

Roentgenologic examination showed the duodenal cap to be grossly irregular and there was pseudopenetration of the lesser curvature base (Fig 315)

At operation April 24, 1939, marked induration in the duodenum was found. The induration extended low in the duodenum and involved the common bile duct. Partial resection was done. It was thought unwise to attempt removal of the ulcer. Closure of the duodenal stump was obtained by retaining some of the pylorus and inverting this portion of the stomach above the ulcer, thus a Finsterer



Fig 316 (Case IV) —Resected stomach prior to reoperation. This is a high resection. The gastrojejunal stoma is small, funnel shaped and rigid, due to recurrent ulcer. The pyloric antrum was removed at the second operation.

evidence of gastrojejunal ulcer was found (Fig 316). Gastric analysis revealed free acid of 10 and total acids of 30.

A second operation was performed May 17, 1940. A large gastrojejunal ulcer was found. The antral portion of the stomach with the duodenal ulcer was removed and a higher resection of the stomach, removing the jejunal ulcer, was done. The pathologic diagnosis was acute and chronic jejunal ulcer.

Following this operation recovery was again uneventful and the patient was discharged eighteen days following operation. Follow up reports indicated that the patient has remained free of symptoms, has gained weight and felt generally in good health.

Comment—This case illustrates the danger of ulcer recurrence when the pyloric end of the stomach with the ulcer in the duodenum

is allowed to remain. Recurrent ulcer occurred within five months after the initial resection. Reoperation was necessary, at which time the pyloric end of the stomach was removed, and the gastric stump with the ulcer was again resected.

One should always suspect that the Finsterer prepyloric type of resection has been done in a case of gastrojejunal ulcer which has occurred after a high and otherwise properly executed partial resection. This retained pylorus should always be sought for at reoperation and, if present, removed. As indicated previously, simple removal of such a retained pyloric portion of the stomach will result in relief of ulcer distress without removal of the gastrojejunal ulcer, provided high partial resection has been previously done. The following case is illustrative of this

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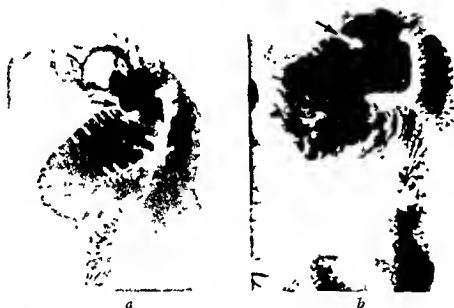


Fig 317 (Case V) —a, Gastrojejunal ulcer is indicated by an arrow. On September 21, 1943, the retained pylorus only was removed.

b, Twenty-one days after operation there is apparent disappearance of jejunal ulcer. A roentgenogram taken on November 9, 1943, failed to demonstrate an ulcer.

CASE V—This patient was first admitted March 8, 1930, for treatment of duodenal ulcer. He was readmitted May 3, 1936, with massive hemorrhage from the ulcer. A Finsterer type of prepyloric resection was done on July 2, 1936, and the ulcer left *in situ*. Onset of recurrent epigastric distress occurred five months later and in August 1937 he had recurrent gastric hemorrhage. The free hydrochloric acid was 60 and total 78. Roentgenograms demonstrated a gastrojejunal ulcer. The pain and distress continued, accompanied by gross bleeding at intervals. Finally he was readmitted and reoperated on September 8, 1941, at which time a large jejunal ulcer was removed, with resection of a portion of the stomach; the pyloric portion of the stomach was not removed.

The patient had recurrence of distress again in four months and on June 26 1942 the roentgenogram showed a large jejunal ulcer. He was readmitted to the hospital September 19 1943. The free hydrochloric acid was 41 total 73 red blood cells numbered 3 170 000. Pain in the epigastrium was severe and morphia was required for relief. He was reoperated on September 21 1943 at which time the retained pylorus only was removed a large gastrojejunal ulcer was not disturbed. Improvement was rapid with complete relief of all distress. Postoperative gastric analysis revealed free hydrochloric acid of 8 and total acids of 14. On roentgenologic check up examination November 9 1943 no evidence of gastrojejunal ulcer could be demonstrated and there was no tenderness in the region of the gastrojejunal stoma. At the last check up examination (Fig 317) on January 4 1946 the patient was quite well and had had no distress since the pyloric part of the stomach was removed. This patient has not had ulcer distress for more than two years since the last operation whereas the previous longest period of relief was five months after the first resection. He has gained weight and has felt in excellent health.

SUMMARY

Over a period of five years from 1941 to 1945 inclusive, there have been 69 resections for gastrojejunal ulcer in a total group of 289 consecutive cases in which resection was required for ulcer. Of this group of 69 cases ulcer developed after gastroenterostomy in 60 after an adequate partial resection in 5 and after the Finsterer prepyloric resection method in 4.

We wish to emphasize the importance of performing an extensive resection of the stomach and complete removal of the duodenal ulcer if surgical treatment of peptic ulcer is found to be necessary. Furthermore it is emphasized that there is considerable danger of gastrojejunal ulcer occurring after gastroenterostomy and that this operation should seldom be employed except in carefully selected cases.

There is a grave tendency to formation of gastrojejunal ulcer when the Finsterer prepyloric type of resection is employed. This retained antral or pyloric portion of the stomach must be removed at a later operation if recurrent ulcer is to be avoided.

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of damage, the presence or absence of which can be ascertained only by careful search of the facial nerve in the path of the wound. The facial nerve, in 1 case in this series, presented a large neuroma at the level of the stylomastoid foramen, partial destruction of the cervical trunk and avulsion of the pes anserinus and adjoining branches. Gutter wounds of the temporal bone superior to the external auditory canal and those grazing the mastoid process are prone to produce a concussion type of paralysis. These patients recover spontaneously and require only debridement of the wound and local repair of the soft tissue and bony defect. Wounds involving the mastoid process at the level of the external auditory canal or below produce facial paralysis as a result of contusion or destruction of a segment of the facial nerve. Penetrating or perforating wounds in which the point of entrance or exit is situated just anterior to the lobule or tragus of the ear offer a poor prognosis for reconstruction of the continuity of the facial nerve as the pes anserinus may be destroyed. Branches of the facial nerve, in its arborization to the facial muscles, are, on occasion, contused or severed by deep lacerations and result in either complete or partial paralysis of the facial musculature, depending upon the extent and location of the wound.

In addition, the character of the agent producing the paralysis is of significance in determining the nature and extent of the lesion or lesions incurred by the facial nerve. While it has been impossible to obtain this information in each case due to the casualty's lack of definite knowledge regarding this point, sufficient data have been accumulated to permit an evaluation of the effect of blast and high and low velocity missiles upon the facial nerve.

The blast of nearby explosives apparently produces facial paralysis as a result of an intraneural pathologic change, precipitated by the pressure waves associated with such explosions, as in no case was a fracture of the temporal bone discernible by roentgenologic examination, and spontaneous recovery occurred. Deafness and rupture of the tympanic membrane, as further evidence of the blast effect, were noted in each case.

Facial paralyzes secondary to high or low velocity missiles, on the other hand, are almost always associated with fractures of the temporal, mandibular or maxillary bones and palsy occurs as a result of concussion, compression, contusion or interruption of the nerve. Little difference has been noted between the amount of destruction caused by either of these two projectiles. The former produces either wounds of the perforating type, with small entrance and exit points, and extensive fracturing of the mastoid process, or large gutter wounds of the soft tissue and relatively slight disruption of the mastoid. The flat trajectory characterizing such missiles and causing roughly horizontally lying wounds tends to involve the vertical portion of the

facial nerve in the region of the stylomastoid foramen and the cervical trunk or its facial distribution. Injury to the facial nerve by low velocity missiles is almost always associated with extensive fracturing of the mastoid process. Such wounds are of the penetrating type and present wide destruction of the nerve. Occasionally minute metallic fragments may either enter the external auditory canal or pass between the stylomastoid foramen and the mastoid tip to section or contuse the facial nerve.

The most important feature of those wounds which resulted in interruption of the facial nerve was the magnitude of the loss sustained by the nerve. Exploration of the facial nerve, in several instances, demonstrated the facial nerve to be either missing or so badly traumatized as to require excision from the region of the geniculate ganglion to within a few millimeters of the pes anserinus, a distance of approximately 65 mm. Losses involving a portion of both the mastoid and cervical segments were common. Infrequent, but offering an extremely poor prognosis for repair of the nerve, were those wounds which destroyed the pes anserinus as well as its immediate branches. Avulsion of the facial nerve in its petrosal course occurred in one case in this series. Interruptions of lesser magnitude did occur and were located usually in the cervical trunk or in the facial distribution.

Civilian experience would lead one to believe that the approximate site of the injury to the nerve, as well as whether it had been severed or not, could be obtained by adequate roentgen studies, electrical reaction and tests for taste and tearing. However, in this series such examinations were of relatively little practical value.

Taste testing as a diagnostic procedure to determine the location of the injury to the facial nerve was unreliable in the majority of the patients. The failure can in all probability best be explained on the basis of the severe concussion which the nerve had sustained. Tests for the presence or absence of lacrimation were more reliable. Roentgenologic studies were difficult to evaluate in determining the location of the lesion incurred by the facial nerve because of failure of the bone fragment to be displaced in the presence of an existing fracture or of an inability to determine which fracture was producing the injury to the facial nerve. Faradic stimulation was of some use in evaluating those paralyses occurring secondary to concussions or in making the decision whether or not to explore a large wound in the vicinity of the parotid gland. Galvanic response always was present in those cases tested.

TREATMENT

The treatment of facial paralysis secondary to compression, laceration or interruption of the facial nerve at any point in its pathway through the temporal bone, neck or face secondary to war wounds is

surgical An exact knowledge of the anatomy of the facial nerve and the pathologic processes within the middle or inner ear with which such lesions are most commonly associated, is a prerequisite for surgical intervention On occasion, a well trained otologic surgeon is best able to satisfy these criteria but in general, a qualified otolaryngologist and neurosurgeon, working together, obtain the most satisfactory results in accomplishing such difficult surgery

The ultimate goal of surgical procedures upon the facial nerve is the physiologic restoration of its function Operations, such as *decompression, end to-end suture, nerve grafting, or anastomosis of the distal stump of the facial nerve to the central end of an adjacent cranial nerve*, effect this result in the majority of cases *Decompression* is readily achieved following the accomplishment of either a simple, modified radical mastoidectomy or classical radical mastoidectomy, as may be indicated by the pathologic process present Exposure of the facial nerve within the fallopian canal is obtained by removing the posterolateral bony canal wall widely on either side of the lesion until normal nerve tissue is observed, and may or may not be followed by slitting the sheath of the nerve, depending on whether or not the operator believes that internal as well as external neurolysis is required Facial paralysis secondary to compression by displaced fragments of bone, foreign bodies or edema may be relieved in this manner

Division of the facial nerve requires that the divided ends be resected until the essentially normal anatomical structure of the nerve is revealed and the continuity restored whenever possible by *end to-end suturing or nerve grafting* When there has been but little loss of substance, the junction may be obtained by mobilizing the distal segment in the neck and parotid gland from the surrounding soft tissue and the exertion of posterior traction to gain about 6 mm Greater losses may be overcome by rerouting the nerve, should the pathologic process present permit a radical mastoidectomy Bunnell stated that gaps up to 23 mm in extent may be closed in this manner¹

Rerouting the facial nerve is a simple surgical procedure Following the performance of a classical radical mastoidectomy, the facial nerve is uncovered sufficiently to permit lifting it out of the fallopian canal without undue trauma from the geniculate ganglion to the stylomastoid foramen (Fig 318, *a*) The cervical trunk of the facial nerve is liberated from the surrounding soft tissues and if necessary, the dissection carried forward into the cheek so as to obtain greater mobilization of this portion of the nerve Removal of the vaginal process of the temporal bone allows the nerve to be redirected so that it courses from the geniculate ganglion vertically across the middle ear into the neck, and permits *end to-end suture* without tension (Fig 318, *b*) Such a procedure does not seriously interfere with the blood

supply of the nerve and, if it is believed desirable, the blood supply may be augmented within the mastoid cavity by covering the nerve with a slip of the temporalis muscle with its pedicle maintaining its blood supply from the temporalis artery.

If approximation of the divided ends cannot be accomplished by either of these methods, then recourse must be taken to *nerve grafting* in order to close the defect. For this purpose it is convenient to utilize the anterior femoral cutaneous nerve as the donor although the sural, great auricular nerve from the cervical plexus or an intercostal nerve may be used as desired by the operator. The latter is more difficult to obtain but is somewhat more desirable because of its firmer consistency and the larger diameter of its tubules. In this series, the anterior femoral cutaneous nerve of the thigh was used in all cases as



Fig. 518.—Reuniting facial nerve. *a*, Facial nerve uncovered in facial canal. *b*, End-to-end suture accomplished.

the donor. The anterior femoral cutaneous nerve is readily located as it pierces the fascia lata and passes over the sartorius muscle through an oblique incision over the anterior aspect of the thigh approximately 1 fingerbreadth below the inguinal ligament. Whether a fresh nerve graft or a predegenerated nerve graft should be utilized is immaterial with respect to the functional recovery obtained, but the latter is more easily handled because of its increased consistency and, therefore, probably permits better coaptation of the suture line.

Nerve grafting is accomplished after carefully exposing the lesion of the facial nerve and shaving the divided ends until healthy nerve tissue is apparent, and measures have been taken to insure a bloodless operative field. A segment is obtained from the donor nerve measuring slightly more than the gap between the freshened ends of

the facial nerve and is inserted into the defect of the facial nerve so as to allow coaptation of the ends of the graft with those of the facial nerve. A nerve graft lying within the fallopian canal in all probability does not require suturing but it is believed that properly placed sutures enhance the neural junction. In those cases in which the opposing ends lie in soft tissue however a single through and through suture of tantalum wire three thousandths of an inch in diameter is necessary in order to prevent separation. The suture should be placed so that the points at which it pierces the nerve and the graft lie approximately 2 to 3 mm from the junction.

A single through and through stitch of fine tantalum wire was used in this series whenever it was deemed necessary to maintain the neural junction rather than several perineural sutures. It was believed that better apposition of the nerve ends particularly with reference to the central portion of the nerve graft could be obtained in this way and that the trauma incident to the passing of several sutures through the perineurium was reduced to a minimum. Spurling has demonstrated that tantalum is relatively inert in peripheral nerves and that this method of nerve suturing is practical.

Occasionally the central end of the facial nerve is inaccessible and as a last resort in such instances *anastomosis of the distal stump of the facial nerve with the central end of an adjacent motor nerve* is necessary. For this purpose the spinal accessory or hypoglossal nerves are admirably suited. Prolongation of the postauricular incision downward into the neck along the anterior border of the sternocleidomastoid muscle permits exposure and mobilization of the central portion of either of these nerves. The peripheral end of the facial nerve is freed and the anastomosis effected and maintained by a single through and through tantalum wire suture. The descendens hypoglossi is sectioned and the proximal end sutured to the distal stump of the donor nerve in an effort to maintain tone in the muscles supplied by this nerve. Opinions pro and con exist as to whether the hypoglossal or spinal accessory nerve should be utilized for this surgical procedure but as a general rule hypoglossofacial anastomosis should be reserved for those individuals whose livelihood depends on manual labor while spinofacial anastomosis is desirable in those whose occupation is of a sedentary nature.

On rare occasions none of these procedures is applicable and in *dwelling mechanical support* must be supplied in order to obviate the unsightly deformity of the face. Total loss of the pes anserinus and inability to locate the severed branches of the facial nerve in its facial distribution are examples. Living mechanical support may be obtained by implantations of fascia lata slings. This is best accomplished by undermining the skin and immediate subcutaneous tissue over the entire affected side of the face through a hockey stick incision over

the temporalis muscle and threading strips of freshly obtained fascia lata through the deeper substance of the face by means of a suitable facial needle in such a manner as to form three loops of fascia, one each running to the upper and lower lip and a third to the angle of the mouth. It is important that the fascial loops which are incorporated in the lips extend past the midline. The free ends of the fascial loops are adusted and anchored within the temporalis muscle so as to cause overcorrection of the facial deformity. Excess skin is excised, the incision closed and a pressure dressing applied to the face. An excellent cosmetic result when the face is in repose may be obtained with this method and slight animation of the paralyzed face may occur when the temporalis muscle contracts.²

Each of these methods of treatment was employed in this series as the pathologic process present indicated and the patient's condition permitted. The facial nerve was decompressed in 7 instances. Laceration or contusion of the facial nerve had occurred within the middle ear in 1 of these patients, in the mastoid in another and in the facial distribution in the remaining 5. End-to-end suture of the distal and proximal ends of the interrupted facial nerve was accomplished in 4 cases. Division of the cervical trunk was present in 2 cases and a neuroma, secondary to a fracture passing through the stylo-mastoid foramen, required excision in a third. The remaining patients exhibited division of two of the principal branches of the nerve in its facial distribution.

Restoration of the anatomical continuity of the divided nerve was obtained in 9 cases by nerve grafting. Both fresh and predegenerated nerve grafts were utilized, the former on 5 occasions and the latter on 4. The choice of a fresh or predegenerated graft was dependent upon the relative diameters of the facial and donor nerves. Thus, if the donor nerve was small, it was crushed and allowed to degenerate for about two weeks so that the resultant increase in size of the peripheral portion would more closely approximate the diameter of the facial nerve. If, on the other hand, there was not too great a difference in the diameters, a fresh nerve graft was used.

Defects in the facial nerve ranging from 15 mm. to 50 mm., the average being 35 mm., were closed in this manner. A 15 mm. graft was utilized to repair a gap entirely confined to the cervical trunk of the facial nerve, while grafts of 25, 30, 35 and 40 mm. were used to repair lesions located both in the cervical and mastoid course of the nerve. Grafts of 45 and 50 mm. were utilized to replace missing segments of the facial nerve extending from the knee to the pes anserinus. The remaining case required a nerve graft of 50 mm. to restore the continuity of the facial nerve from immediately anterior to the horizontal semicircular canal to just distal to the stylo-mastoid foramen.

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Each of these methods of treatment was employed in this series as the pathologic process present indicated and the patient's condition permitted. The facial nerve was decompressed in 7 instances. Laceration or contusion of the facial nerve had occurred within the middle ear in 3 of these patients, in the mastoid in another and in the facial distribution in the remaining 3. End to end suture of the distal and proximal ends of the interrupted facial nerve was accomplished in 4 cases. Division of the cervical trunk was present in 2 cases and a neuroma, secondary to a fracture passing through the stylomastoid foramen, required excision in a third. The remaining patients exhibited division of two of the principal branches of the nerve in its facial distribution.

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The facial nerve was absent in its petrosal intratympanic and superior half of the mastoid course on one occasion. Repair was effected by anastomosis between the distal stump of the facial nerve and the central stump of the hypoglossal nerve in this case. In 2 instances the pes anserinus and its immediate branches could not be found and the facial deformity was satisfactorily corrected in 1 by fascia lata implantation. The other together with a patient in whom the facial nerve was absent from just anterior to the horizontal semicircular canal to it is believed the pes anserinus had to be returned to the zone of the interior before further treatment of the facial paralysis could be effected. The continuity of the nerve could not be reestablished in 3 instances in which the interruption of the facial nerve occurred in its facial distribution.

The adequate treatment of facial paralysis should incorporate not only the specific repair of the lesion of the facial nerve but also *therapy directed toward the facial musculature* in an effort to prevent undue sagging of the paralyzed side of the face. This is particularly true if it is anticipated that the facial paralysis will exist for a considerable period of time. Permanent sagging of the soft tissues and atrophy of the muscles will be reduced to the minimum if mechanical support and daily massage are instituted early. The paralyzed muscles of the face in this series have been supported by adhesive traction or by fascia lata slings or strips. The latter method is desirable not only because it provides more natural support to the paralyzed face but also because permanent correction of the facial asymmetry is obtained in the event that functional restoration of the facial nerve fails to occur. The cornea was protected and the epiphora benefited in the majority of these cases by a lateral tarsorrhaphy.

The method of fascia lata implantation utilized in the majority of cases in this series was developed after experience gained with the Ferris Smith fascial needle. Considerable discomfort and edema of the face are present after fascia lata loops are placed with this needle because of the resultant trauma to the deeper soft tissues of the face. However the greatest impetus to devise a modification of this method of supporting the paralyzed face during the period of recovery arose with the realization that in all probability a number of the secondary branches of the facial nerve were severely traumatized or severed by the passage of such a large bore needle and consequently possibly decreased the degree of functional recovery that might be expected.

It was believed that if a needle of appreciably smaller diameter could be passed a fewer number of times the possibility of permanently injuring the branches of the facial nerve in the soft tissues of the face would be decreased or entirely avoided. Consequently a number 14 malleable hollow steel needle 12 inches long was obtained from a manufacturer of surgical instruments. A length of soft

steel wire of suitable size was threaded through the bore of this needle in such a manner as to provide a loop at the pointed end of the needle which could be protruded from or withdrawn into the lumen of the needle as desired.

An adequate amount of fascia lata was obtained from the iliotibial band with a fascial stripper and fashioned into three strips approxi-

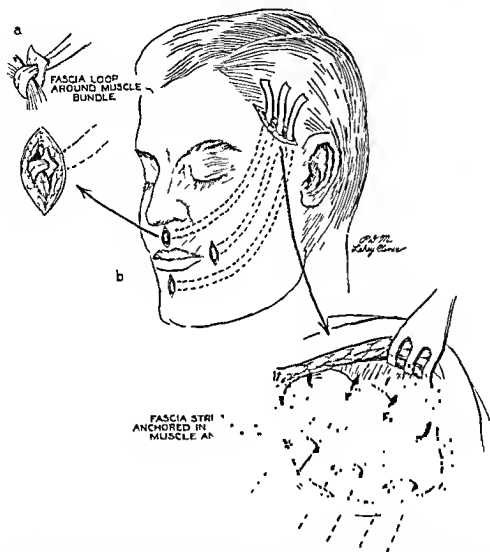


Fig. 319.—Fascia lata support to paralyzed face. *a*, Anchoring end of facial strip about orbicularis oris muscle. *b*, Location of fascial strips. *c*, Anchoring end of fascial strip in temporalis muscle and fascia.

mately 6 mm. wide and 18 cm. long. A small incision was made at the midpoint of the width of each strip a few millimeters from one end. Following the preparation of the strips, a short vertical incision was made through the skin and subcutaneous tissue of the upper and lower lip a few millimeters past the midline so as to expose the fibers

of the nonparalyzed portion of the orbicularis oris muscle. The orbicularis oris muscle on the paralyzed side of the face opposite the angle of the mouth was similarly exposed. A hockey stick incision was made to the temporal fossa exposing the temporalis fascia and muscle.

A bundle of the orbicularis muscle is isolated through the previously prepared incision in the upper lip and the end of the strip of fascia passed around the muscle bundle. One end of the strip threaded through the small slit near the opposite end and the loop thus formed drawn snugly around the muscle bundle and anchored in place with a silk suture (Fig 319 a). The previously described needle with its wire loop contained within its lumen is passed from the temporal incision through the soft tissues of the face in such a manner as to emerge at the incision in the upper lip. The wire loop protruded the free end of the fascial strip firmly grasped by the loop being pulled firmly against the end of the needle and the needle as well as the free end of the fascial strip withdrawn through the soft tissues of the paralyzed face to appear in the temporal incision.

A similar procedure is followed with the remaining two strips of fascia lata for the lower lip and corner of the mouth. Sufficient traction is applied to the free ends of the strips presenting at the temporal incision to over correct the sagging of the soft tissues of the paralyzed side of the face (Fig 319 b) and maintained in this over corrected manner by weaving the free ends of the three fascial strips through the temporalis fascia and muscle (Fig 319 c) which are in turn, anchored by silk sutures. The skin incisions are closed and a pressure dressing applied to the face.

Exploration of the facial nerve in the operated cases of this series proved to be especially difficult because of the loss of established anatomical landmarks in relationship to the nerve in its course through the temporal bone and also because of the displacement of the nerve within the soft tissues of the neck and face by the wound-healing agent. The surgeon operating in cases of facial paralysis incurred as a result of war injuries must be thoroughly conversant with the anatomy of the region and be blessed with an infinite amount of patience and perseverance.

No attempt has been made to describe the results obtained in this series as it has been impossible to obtain necessary data in all cases due to the wide geographic dispersal of the patients involved and the difficulty in obtaining suitable follow up reports in the form of either pictures of the patient or an evaluation of the degree of recovery by a local physician. This information is being assembled and will be published in a subsequent report. However since restoration of the anatomical continuity of the facial nerve has been accomplished in most patients it is believed from previously reported experience with such methods of nerve repair that relief of the facial paralysis will be

obtained, which will be of decided benefit to the individual afflicted with a complete peripheral facial paralysis. It is not anticipated that the degree of recovery obtained in the cases reported in this series will be entirely comparable to traumatic lesions of the facial nerve encountered in civilian life because of the severe injury sustained by the facial nerve, whether it be single or multiple.

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THE ROLE OF MINOR PROCEDURES IN THE TREATMENT OF TRIGEMINAL NEURALGIA

GILBERT HORRAX

For the past twenty five years the operation of partial or complete sensory root section for the permanent relief of trigeminal neuralgia has become so standardized and so relatively safe when performed by competent neurosurgeons that one may properly ask why this is not always the procedure of choice when dealing with a well recognized case of *tic douloureux* of the fifth nerve. There are many factors to consider before this question can be answered satisfactorily and it is the purpose of this communication to set forth the various considerations which make some of the so called minor procedures preferable under certain circumstances.

In deciding for or against the sensory root operation one must at least candidly admit the following points: first, that the operation although relatively safe, does carry a slight mortality, 0.5 to 1 per cent in trained hands, and therefore unless the procedure is one of necessity, patients under certain circumstances should not be subjected even to this slight risk. Second, there are definite discomforts in the form of paresthesias which follow the cutting of any nerve, and these discomforts are permanent and unchangeable after root section. Probably 5 to 10 per cent of patients continue to complain bitterly of these "burning" or "gnawing" or "pulling" sensations which seem to annoy them almost as much as the old pain. Third, there is the danger of an anesthetic cornea in patients who have to have the whole root divided because of pain in the upper two divisions of the nerve and in spite of all precautions occasional corneal ulcers develop. A fourth factor is, of course, the somewhat added danger of any major operation upon patients who have serious systemic disease if relief can be had safely by simpler means.

Medical Therapy.—What, then, are the "minor procedures" which can be used for the relief of patients with *tic douloureux* and when should they be used? In the first place, there are certain types of medication which may be tried, although most of these are of questionable value. They are indicated only in patients who do not have extremely severe and persisting paroxysms, and may in some instances tide the patients over a troublesome period of pain until the neuralgia ceases either because of or in spite of the medication. Of all medicines, the inhalation of *trichlorethylene* (trethylene) is without much question the most efficacious. Twenty five drops of the drug should

be inhaled regularly by the patient three to four times daily, and this should be kept up for at least one to two weeks or for many weeks if it appears to be helpful. The best way to take this form of medication is to have the patient put the drops on a piece of cotton in the bottom of a water glass then lie down on his side and immediately inhale deeply. Inhalation may make a person feel a little "dizzy," but if consciousness should be lost, the glass will fall from the hand. I have not known this actually to happen but it is theoretically possible, as trethylene is an anesthetic if taken in larger doses.

Another recent form of medication consists in large doses of *thiamine chloride* given intravenously. We have given 100 mg. for the first dose and then 50 mg. daily for a week. A second week of 50 mg. daily may be tried if this form of therapy seems helpful. We have felt that in a few patients with so-called "minor" trigeminal neuralgia this treatment with thiamine chloride appeared to be beneficial.

Many other medicines have been tried but none are specific. It is hardly necessary to say that no opiates should be given unless a patient is being transported to a place where definitive surgical relief is contemplated, or as a purely temporary measure on rare occasions.

Alcohol Injections—Of all the minor procedures for the relief of trigeminal neuralgia, alcohol injections into the various branches of the nerve are by far the most helpful and are as a rule, easily and quickly accomplished by those who have been trained in their use. It is pertinent, therefore, to discuss some of the pros and cons of alcohol injections and to state the case for their usefulness. This is in no way to disparage the operation of sensory root section which, when indicated, gives most gratifying results in a high percentage of cases.

It should be stated at the outset that alcohol injections are useful almost exclusively in dealing with neuralgias in the middle and lower (second and third) divisions of the trigeminal nerve. In supra-orbital neuralgias it is much more satisfactory to do a supra-orbital neurectomy if a minor procedure is contemplated. Some of the supra-orbital branches are so small that it is impossible to inject them with alcohol.

It should also be stated that for an alcohol injection to be successful the needle must be inserted into the nerve and the alcohol injected into the nerve substance. If it is injected outside the nerve, even slightly into the surrounding tissues the effect will be an increase in pain and not relief.

The chief indications for alcohol injections are the following:

- 1 To give quick relief to patients who are having acute pain. It is not always possible to obtain a bed or a room for a patient in a hospital where the sensory root operation can be done. The injection can be done easily on any examining table in or adjoining the sur-

Peripheral Neurectomies—Any one of the three main branches of the trigeminal nerve may be sectioned in its peripheral distribution and temporary relief obtained for one or two years and occasionally longer. By far the most usual and most useful of these peripheral operations is the supra orbital neurectomy. It happens not infrequently that one will see patients who are suffering from a pure supra orbital neuralgia without any involvement of the deeper filaments of the first division and no spread to the lower divisions of the nerve. Rather than do a differential section of the nerve root, which in this instance would be considerably more difficult than a differential section of the fibers to the second and third divisions, it is almost always preferable to do the peripheral operation. Furthermore, by the excision or avulsion of the supra orbital fibers no corneal anesthesia results and this would be an added complication with section of the first division fibers of the root. As mentioned previously, supra orbital neurectomy is likewise nearly always indicated in preference to an attempt to inject the nerve above the eyebrow with alcohol. This is because there are several separate branches of the supra orbital nerve and not a single group of fibers as in the case of the infra orbital and mandibular divisions. Supra orbital neurectomy is also of value in patients whose neuralgia has advanced to the upper division of the nerve after section of the lower two thirds of the root has been performed previously. Here again one or more years of relief may be obtained without subjecting the patient to the risk of an anesthetic cornea and threat of keratitis. The supra orbital operation is extremely simple, takes but a few minutes and the inch and a half incision through the shaved eyebrow of course leaves no scar. The patient's hospital stay need not be more than forty-eight hours. Furthermore, the operation may be repeated several times if the occasion warrants it and the patient is satisfied with the length of relief.

Infra orbital neurectomy is sometimes a helpful operation when alcohol injections of this nerve for patients with a purely infra orbital neuralgia have become difficult because of scar tissue. Many patients will prefer the localized and transient numbness of such an operation rather than the more widespread permanent anesthesia which follows partial root section, even though they realize that this operation or the operation on the root will have to be performed at some future time when their pain recurs. We always perform the infra orbital neurectomy by a small incision through the upper gum as advocated by Coleman.² It is an extremely simple procedure and, just as supra orbital neurectomy, leaves no visible scar. Patients should be able to leave the hospital after two days. Peripheral neurectomy of the mandibular branch of the trigeminal is rarely called for but I have used it in a few instances. Almost always the third division can be injected satisfactorily with alcohol at the foramen ovale, but occa-

sionally in a bilateral neuralgia, when the sensory root has been divided on one side and alcohol injection has become difficult on the other, it may be wise to temporize with an avulsion of a portion of the mandibular branch. This can be done quite easily by a $1\frac{1}{2}$ inch incision just below the angle of the jaw and, after separating the fibers of the masseter muscle, a small bur opening is made in the mandible down to the canal of the inferior dental nerve. The nerve is then avulsed by gradual traction first on its peripheral end and then centrally.

SUMMARY

Although partial or complete section of the sensory root of the trigeminal nerve is an extremely safe and usually satisfactory operation for tic douloureux it has certain drawbacks and is not the procedure of choice in every case of trifacial neuralgia.

Alcohol injections should be employed in most instances as a temporary measure for the following purposes

1 To give quick relief to patients suffering severe pain when hospitalization cannot be obtained

2 To accustom patients temporarily to the annoyances of the anesthesia and paresthesias which they will have permanently and irreversibly after root section

3 To make certain of the diagnosis of trigeminal neuralgia in certain doubtful cases

4 To relieve very elderly or extremely poor risk patients as a safer measure than operation

5 To afford relief to patients with bilateral neuralgia rather than to subject them to complete permanent anesthesia on both sides of the mouth and tongue

6 Peripheral neurectomies particularly supra orbital neurectomies, are extremely useful at times when alcohol injections are difficult or impossible and the sensory root operation seems inadvisable

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REFLEX SYMPATHETIC DYSTROPHY

JAMES A. EVANS

INTO an institution such as the Lahey Clinic is likely to filter the bizarre and unusual case the tough diagnostic and therapeutic problem that has been seeking relief from pillar to post for many years. Into this category falls the patient with reflex sympathetic dystrophy (causalgia Sudeck's syndrome). Four to eight years of suffering is a common story of our patients with this most distressing phenomenon. One young lady described most vividly the intense suffering she had endured for twenty five years putting her shoe on each morning this act requiring thirty minutes each day. Indeed she had acquired a conditioned reflex breaking out in a cold sweat as the examiner approached her foot with his hand to feel it.

The commonly used term "causalgia" is really a misnomer since a few of these patients do not have pain. The characteristic features are those due to stimulation of the sympathetics in the part involved namely rubor pallor or a mixture of both sweating and atrophy even spotty or cystic bone atrophy (Sudeck's syndrome).

Reflex sympathetic dystrophy most commonly follows old fractures sprains lacerations or gunshot injury to nerve trunks and blood vessels.

TABLE 1—ORIGINAL INJURY OR DISEASE

32 Cases			
Sprain	9	Scalenus Syndrome (?)	1
Fracture	5	Laceration of Hand	1
Thrombophlebitis	4	Anterior Poliomyelitis (?)	1
Poor Foot Statics	3	Plantar Wart	1
Bruise	2	Gonorrheal Arthritis	1
Amputation	2	Thalamic Syndrome	1
		(cerebrovascular accident)	

COMPLICATIONS

Fungus Infection	3
Operative Interference	3

We have seen it also after infantile paralysis poor foot statics gonorrheal arthritis phlebitis or amputation. Table 1 enumerates the causes in 32 of our collected cases.

PAIN

Some pain is almost always present and may be so severe and so long persistent that the patient contemplates suicide. Causalgic pain arising from aberration of sympathetic control has characteristic

features of its own. It is a deep, boring "toothache-like" pain, diffuse in its distribution, difficult for the patient to localize, not felt precisely in the area of the old injury. Manipulation, as in physiotherapy, and use of the limb involved aggravate the suffering. It is often described as "burning." One or more trigger areas are present. These trigger zones may be widely separated and some of them far from the site of original injury. A chief trigger zone is usually found near the original injury, however, and blocking this area with procaine may submerge the other trigger points. Thus, blocking a trigger point is one of our chief diagnostic and therapeutic methods of attack. Pressure on a trigger point characteristically causes a diffuse spread of the pain over a wide area, most characteristically up the limb.

TABLE 2.—PAIN

Causalgia	8
Severe	8
Moderate	12
Mild	2
None	2

In our 32 cases (Table 2), trigger points, single or multiple, were found in 19. Pain was excruciating and of a burning, causalgic nature in 8, rated severe in 8, moderate in 12, mild in 2, and none existed in 2 cases. These last two patients showed other signs of reflex sympathetic dystrophy.

OTHER SYMPTOMS AND SIGNS

Rubor was present in 16 and *pallor* in 8 cases (Table 3). The *rubor* may be so constant and the foot or hand be so hot that the picture of erythromelalgia is produced. In 6 cases *rubor* was present and of

TABLE 3.—OTHER SYMPTOMS AND SIGNS

Trigger points	19
Rubor	16
Pallor	8
Swelling	17
Sweating	17
Atrophy	22
Skin	4
Muscle	7
Bone	11
Mottled or cystic	6
Diffuse (disuse)	5
Cramp	3

one year's duration or more, and in 1 case for as long as twenty-eight years. *Swelling* and/or *sweating* was present in over half of the cases. *Atrophy of the skin* was noted in 4 and of *muscle* in 7 patients. The

typical bone atrophy of sympathetic origin is mottled, in advanced cases even cystic, presumably owing to nutrient artery spasm. Such bone atrophy was described in the roentgenograms of 6 patients in this series. A diffuse osteoporosis resembling that of disuse was noted in 5 cases.

DIAGNOSIS

Either cervical or paralumbar sympathetic procaine block comprises a diagnostic therapeutic test. The relief of pain may be almost miraculous but need not be so dramatic to establish the diagnosis provided relief of other phenomena is also noted, such as relief of sweating, increased warmth and comfort in a cold member, associated with rise of skin temperature (temperature index test), and disappearance of trigger points. Nineteen of our 32 patients had blocks performed, with varying amounts of relief in all but one.

MECHANISM OF REFLEX SYMPATHETIC DYSTROPHY

Figure 320 illustrates diagrammatically the nervous pathways giving rise to the syndrome of reflex sympathetic dystrophy. The fundamental concept of the internuncial pool (Fig. 321), advanced by

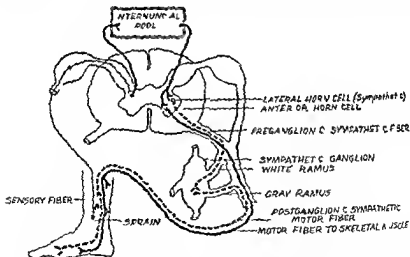


Fig. 320—Reflex arc of sympathetic dystrophy embodying Lorente de No's theory of the internuncial pool (Fig. 321). See text for explanation.

Lorente de No and adopted by Livingston, can be explained simply as follows. A prolonged bombardment of pain impulses sets up a vicious circle of reflexes spreading through a pool of many neuron connections upward, downward and even across the spinal cord and perhaps reaching as high as the thalamus itself. Because of the summation principle of nervous impulses there is kept alive within such a

pool a constant circling of activity across the synapses involved. Some of these synapses include the sympathetic motor neuron cells in the lateral horn controlling vasomotor tone and the sweat glands. Spasm in the arteriolar and venule end of the capillary loops raises filtration pressure, and edema and swelling result. Anoxemia increases capillary permeability and filtration, further augmenting edema. Other synapses involved may be the anterior motor horn cells, giving rise to skeletal muscle cramps and spasms. Out of the pool also arise

INTERNUNCIAL POOL *Closed Self-reexciting Chain*

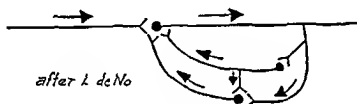


Fig 321

augmented stimuli to pain traveling up the thalamic tract. Depending on the wide spread of the pool we detect the phenomena of pain and sympathetic disturbances observed a long distance from the injured area in the limb and occasionally even spread to the contralateral limb.

TREATMENT

The ideal point of attack would be the internuncial pool itself. So far, no direct effective means is at hand to stop the vicious circle within this pool of neuron synapses.

Two other points of attack exist: the trigger points and the sympathetic pathway. Repeated injections of the trigger points usually are necessary. If the sympathetic pathway is blocked by procaine, one is occasionally gratified by the astounding relief obtained with only one injection. More often, there are relapses within a few days or weeks and repeated injections are necessary at longer and longer intervals. It would seem more logical to give a series of three injections, one every second day, for more permanent rupture of the pernicious reflex, a method so successfully applied to thrombophlebitis (Fig 322).

At the Clinic we have felt it best to resort to sympathectomy in the majority of our treated cases after the demonstration of the efficacy of one block in order to obtain the maximum of relief and the greatest assurance of permanency of relief.

Posterior root rhizotomy, cordotomy or, for high cervical segment,

interruption of the thalamic pathways in the medulla and even resection of the sensory cortex may be necessary in exceptional cases

Nineteen patients (Table 4) received sympathetic procaine block, with varying amounts of relief of pain and sympathetic phenomena in all but one. Nine patients were treated by block alone. Of these 9, 7 had 50 to 100 per cent relief of pain for three weeks to permanent

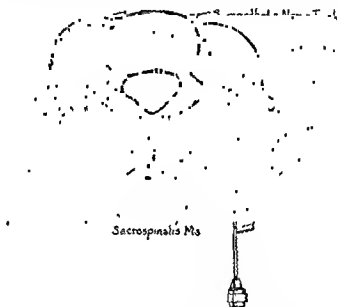


Fig 322—Technique of paralumbar sympathetic procaine block (from Nicholson, *Anesth and Anal.*, May-June, 1942)

relief. Two of the 9 received only temporary relief for the duration of the procaine effect. Only one patient was treated by injection of trigger points as well as by sympathetic procaine block, with relief of pain for only three weeks. A sympathectomy is to be done on this patient. Thirteen patients have had sympathectomy (Table 4) with

TABLE 4—TREATMENT

19 patients had sympathetic procaine blocks, all but one with varying amounts of relief		
Block only		9
Relief 50-100% for 3 weeks to permanent	7	
Temporary relief (duration of procaine)	2	
Sympathectomy		13
Relief ranging from 75-100%	9	
Failure to 25% relief	4	

pain relief ranging from 75 to 100 per cent in 9 (69 per cent). Failure to 25 per cent relief resulted in 4 of the 13 cases.

ILLUSTRATIVE CASE REPORTS

CASE I—A woman came to the Clinic February 16, 1944, because of mild pain, rubor, swelling and slight muscle atrophy which had been present ever since she sprained her ankle nine months before admission. The roentgenogram showed



Fig 323 (Case I) —Mottled bone atrophy of reflex sympathetic dystrophy (Sudeck's syndrome)

mottled bone atrophy (Fig 323). Paravertebral sympathetic block afforded temporary relief. Sympathectomy was done, with 90 per cent relief of pain in two months. At this same time a roentgenogram showed less bone atrophy.

CASE II—A man came to the Clinic August 14, 1944, because of moderate pain in the right foot of six months' duration. There was definite swelling and a blotchy type of bone atrophy. There was no history of trauma but marked pes planus was present. One month after one paravertebral block 100 per cent relief of pain was obtained. The patient also had proper shoes fitted.

CASE III—This man came to the Clinic June 13, 1944. He had suffered from gonorrheal arthritis eight years before admission. There had never been complete subsidence of pain in his right big toe and foot. Hyperhidrosis had been present, complicated by fungus infection, with ulceration. Rubor, swelling and marked sweating were apparent. A roentgenogram showed an aseptic necrosis in

the toe (Fig. 324). The patient also had essential hypertension. For this reason a splanchnicectomy rather than sympathectomy was done. There was 100 per cent relief of the pain in the right foot and toe. Three months later his foot was



Fig. 324 (Case III) —Gonorrheal arthritis eight years before admission as evidence of gonorrheal activity at present. Aseptic necrosis of both phalanges of right great toe. Diffuse osteoporosis of distal tibia. Cured by splanchnicectomy.

dry and the ulcers had healed. A check up roentgenogram of the toe showed the same aseptic necrosis present.

CASE IV —A college girl aged 21 years, came to the Clinic September 7, 1944. She had suffered moderate pain in the right lower leg following a fall skating nine months before admission. Marked swelling and rubor developed. For the past two months purpuric spots had appeared over the right lower leg. Sweating had become pronounced. Soon after the fall she was confined to bed with what was called the "flu". At this time she had fever and red streaks on her leg. A venogram at the time of her hospital entry showed normal filling of the deep veins. Normal capillary fragility. Platelets were normal. "March fracture" (Fig.

This patient was treated with a series of three paravertebral sympathetic procaine blocks in one week. At the end of the week the swelling had subsided and the trigger points had disappeared. She was seen eight months later, and pain had been completely relieved since the blocks.



Fig. 325 (Case IV)—Callus of old march fracture.

The following 3 cases have been added since the original report of 32 cases.¹

CASE V—A woman aged 33, entered the New England Baptist Hospital May 10, 1945, complaining of excruciating pain in the right arm, shoulder and breast, of five years' duration. Six weeks before the onset of this pain she had fallen on the right elbow, and the roentgenologist reported she had sustained a chip fracture of the olecranon process. The trouble began as a painful swelling of the right forearm diagnosed as *neuritis*. The tonsils and appendix were removed as possible foci of infection without relief. Next the arm itself was explored and a biopsy specimen taken. The pathology report from the New Haven Hospital and Dispensary was *periarthritis nodosa*.

In 1942 a nerve block proved ineffective. In 1943 relief was obtained for two years after a scalenectomy. There was a return of symptoms in 1944 attended by severe epistaxis.

Examination revealed a Raynaud like syndrome with trigger points over the scar on the right arm the olecranon process the posterior and medial surface of the upper forearm the back of the right shoulder, and the right posterior aspect of the neck about the level of the second and third cervical vertebrae. Another trigger point was present in the lateral second interspace on the right. Exposure to cold produced whiteness of the hand and forearm followed by blueness. Extreme cold caused complete numbness of the right little finger and proximal interphalangeal joint the latter becoming black in color. The patient stated that when the pain started the right shoulder, breast and arm felt cold and became pale and then swelled followed by the hand becoming white and then blue. This phenomenon was observed during the examination. There was a palpable difference in temperature of the two upper arms. Sweating of the right axilla and hand was noted. There was atrophy of the tips of the fingers in both hands more marked on the right with tapering especially of the tip of the right little finger. The right radial pulse during a paroxysm of pain was barely perceptible. It was thought that her episodes of pain in the left arm might be the contralateral effect sometimes seen in causalgia.

On May 14 1945 the patient was put on a porch where the air was cooler. When she was turned on her left side and the right arm and shoulder exposed the arm became quite painful and was mottled and cyanotic from the shoulder down to and including the hand. A paravertebral metycaine block was done of the seventh cervical and first and second thoracic segments. Almost immediately after the metycaine was injected the patient said that her arm felt warmer and the pain was diminished. Fifteen minutes after the injection was completed the arm was pink and warm. She said there was no pain whatsoever by this time. The trigger areas had disappeared.

With this evidence a right thoracic sympathectomy was performed including the thoracic second and third sympathetic ganglions. Following sympathectomy the pain on the right disappeared and the flushing and sweating phenomena abated.

About a week after the right sympathectomy the patient began to complain bitterly of similar symptoms on the left side. A left upper thoracic sympathetic block caused temporary disappearance of this pain. A left thoracic sympathectomy therefore was done including the second and third thoracic segments. The patient was discharged on the twenty fifth hospital day asymptomatic.

Four months after hospital discharge however the pain returned in an area lower on her chest than the previous symptoms. It may be necessary to extend the sympathectomy to a lower level.

CASE VI—A man aged 64 was admitted to the New England Deaconess Hospital August 18 1945 with pain and swelling of the left hand and forearm of five months duration. A year before admission itching and discomfort of his nose had developed with several small ulcers inside the nose. When these failed to heal a Wassermann was taken which was reported "questionably positive." He was then given an injection of bismuth into the left cubital vein. As the injection was being given the patient jumped and some of the bismuth was injected outside the vein. Shortly thereafter a lump about 4 by 8 cm. formed on the arm. Two weeks later a spot on the left thumb became painful tender red to purple and hot. This spread to involve the entire hand and wrist. At times the fingers became pale and cold and the nails became deathly white. A rash was present for three weeks on the dorsum of the left hand.

Examination showed the wrist and fingers of the left hand to be slightly swollen. The skin was smooth pink and atrophic. There were loss of wrinkles and pitted nails. Ulnar deviation of the wrist was present. The metatarsal phalangeal joints were slightly flexed. The interphalangeal joints of the four fingers were

ankylosed. There was atrophy of the left shoulder girdle. Pigmentation of the skin with scaling was noted over the left pectoral and left supraclavicular regions. There was partial immobility of the left shoulder especially external rotation. A diagnosis was made of reflex sympathetic dystrophy with secondary atrophy of the bone, muscles and joints and ankylosis of the finger joints.

A left cervical sympathetic block was carried out on August 22 with the following results: (1) Shortly after the block the skin of the left hand became redder. One hour later, when holding the hand in the dependent position the left hand became cyanotic. (2) There was definitely decreased pain in the fingers, hand and wrist with abolition of pain at the trigger point at the base of the left thumb. (3) There was increased passive mobility of all of the finger joints and wrists. (4) Skin temperature readings taken on the dorsum of the hand, thumb and forefinger showed a definite increase, a total rise in one hour of 6.3° F. Because of long disuse of the extremity, the patient had "frozen left shoulder." The orthopedist manipulated the shoulder under local anesthesia, breaking down fibrous adhesions. Four days later a left cervical sympathectomy was done by the anterior approach. On the fourth postoperative day postoperative bronchial pneumonia developed which subsided on sulfathiazole therapy. On discharge he was given instructions to use melted paraffin to the hand and given directions as to special exercises.

Two months after discharge marked scleroderma was still present over the second and third fingers and palmar contractions persisted. The left shoulder still had only 60 degrees of motion. Ankylosis prevented closing the hand. The patient complained of pain at the base of the second finger extending up the left arm but this pain was about 50 per cent less than before operation. The chest muscles had filled out; there was very little atrophy of the left shoulder muscles and the pigmentation and scaling of the left pectoral region was entirely gone. Improvement was estimated as about 50 per cent.

CASE VII—A man aged 49 had spent thirteen years tipping a release on a machine 200 times daily, pressing with the sole of his foot on the trip. Five years ago the right ankle started to swell following a day when he had trouble with his machine and had to press on it extra hard. A dull pain started in the right ankle about the same time which caused him to limp. A year ago following an injection of varicose veins about the internal malleolus, red streaks developed up the leg to above the internal side of the knee. Since then the leg had swelled to the knee whereas it used to swell only around the ankle.

Physical examination showed minimal edema of the lower leg on the right. There was a blanched area with swelling and sweating about the left internal malleolus. Ankle cyanosis was present and dorsalis pedis pulsation was absent on the right though a good posterior tibial pulsation could be felt. Both feet felt cold. Roentgenograms of the right foot showed the bones to be normal. The diagnosis was reflex sympathetic dystrophy caused by chronic industrial sprain. Sympathectomy has been advised.

SUMMARY

Reflex sympathetic dystrophy is described as a syndrome produced often by minor trauma or disease in a limb leading to the reflex production of the sympathetic phenomena of rubor or pallor, heat or cold, increased sweating, edema and pain. Since the factor of pain may be absent, the term reflex sympathetic dystrophy is preferred to cruralgia.

The role of Lorente de No's internuncial pool in the production of the syndrome of reflex sympathetic dystrophy is presented

Traumatic injury accounted for only 59 per cent of the 32 cases reported

The typical bone atrophy of reflex sympathetic dystrophy is mottled or cystic (Sudeck's syndrome)

Diagnosis depends largely on the demonstration of relief by sympathetic procaine block Nineteen of the 32 patients received sympathetic block with procaine, with varying amounts of relief of pain and sympathetic phenomena in all but one patient

Treatment may be directed to blocking the trigger points if they exist and to blocking the sympathetic pathway In 9 patients treated by sympathetic procaine block alone, 7 had relief of pain varying from three weeks to permanent such pain relief estimated at 50 to 100 per cent The other 2 received relief of pain only for the duration of the procaine effect

Thirteen patients of the 32 here reported had sympathectomy performed with relief of pain ranging from 75 to 100 per cent in 9 (69 per cent) Failure to 25 per cent relief of pain resulted in 4 of the 13 The 2 patients who had no pain but other sympathetic phenomena have so far not submitted to either block or sympathectomy

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THE SURGICAL CLINICS of NORTH AMERICA

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SYMPOSIUM ON PAIN IN THE SHOULDER AND ARM

INTRODUCTION

H HERMAN YOUNG

PAIN in the shoulder and arm is a common symptom among patients seeking medical diagnosis and treatment. That this symptom may be the result of a serious pathologic lesion that may prove fatal is not generally appreciated by the medical profession at large. In a case which was observed recently in the Section of Orthopedic Surgery, the patient complained of pain in the left shoulder and arm. The pain was present during rest and activity. From the orthopedic standpoint, no lesions could be found to account for the patient's symptom, and a neurologic examination also failed to disclose any abnormality. A cardiologist, who saw the patient in consultation, made a diagnosis of severe cardiac infarction. The patient died a few weeks later. This case emphasizes the seriousness of a lesion which may produce a seemingly minor symptom. According to Bram, the examination of each organ of the body may "seem to be foolish counsel and only counsel of perfection, yet, its neglect sooner or later will lead to the manifestation of a serious disease being mistaken for a trivial local disorder."

In all cases of pain in the arm or shoulder, the physician should obtain a detailed history. This should include the patient's occupation and whether or not an injury preceded the onset of symptoms. Notation should be made of the date of onset of the pain and whether or not the onset was gradual or sudden. The site of the pain should be located as accurately as possible and its character should be recorded, that is, whether or not it radiates or is associated with tenderness, paresthesia or muscular weakness. One should record whether or not the pain is relieved by rest or whether it occurs only on exertion. In the latter case, the type of exertion that produces the pain should be noted. The history also should contain a notation of whether the pain

is produced by physical exertion of the entire body or by local motion of the arm and shoulder. Finally, an accurate history should contain data regarding associated symptoms such as dyspnea, abdominal pain and tenderness, and a record of all factors that aggravate the symptoms.

The second essential procedure in the diagnosis of the cause of pain in the arm or shoulder is a complete physical examination. Examination of the heart, lungs, abdomen, pelvis, rectum and nervous and vascular systems occasionally will disclose a lesion that is producing pain in the arm or shoulder. In cases in which the lesion is localized in the shoulder or arm, the site of involvement should be examined for swelling and tenderness and the limb should be examined for any limitation of active or passive motion. One should search for enlarged supraclavicular or axillary lymph nodes, tenderness of the brachial plexus or ulnar nerve, reflex or sensory changes, venous congestion, abnormal pulsations, bruits, thrills, atrophy and weakness. Finally, roentgenologic examination will be of value in many cases. The extent of this examination should be determined by the results of physical examination.

A physician cannot be a specialist in all branches of medical science, however, in order to make an accurate diagnosis of the various lesions that may cause pain in the arm or shoulder, he should have some knowledge of orthopedics, neurology, cardiology and of diseases of the abdomen, thorax and blood vessels. For this reason, the orthopedic, neurologic, cardiac, thoracic, abdominal and vascular aspects of pain in the arm and shoulder will be considered in this symposium.

THE ROLE OF THORACIC DISEASE IN THE PRODUCTION OF ARM PAIN

ARTHUR M. OLSEN

PAIN that is referred to the shoulders and upper extremities may be caused by several clinical conditions which have their origin within the thorax. Pain of cardiac origin is considered in another section of this symposium. I shall consider referred pain caused by lesions of the superior sulcus of the thorax, pain of esophageal origin and pain caused by disease processes which involve the diaphragm.

LESIONS OF THE SUPERIOR PULMONARY SULCUS

The most common lesion of the superior sulcus of the thorax which causes arm pain is a malignant tumor of the apex of the lung. Malignant tumors of the apex of the lung are usually primary bronchiogenic carcinomas but metastatic carcinoma occurring at this site may produce the same symptoms. The symptom complex which may occur in association with tumors of the apex of the lung was described by Pancoast and has been referred to commonly as the Pancoast syndrome. In addition to a roentgenographic shadow at the apex of the lung the syndrome usually includes a neuritic type of arm pain, atrophy of the muscles of the hand and arm and Horner's syndrome. Roentgenologic evidence of malignant destruction of contiguous ribs may also be demonstrated and sometimes the vertebral bodies are invaded. Moersch, Hinshaw and Wdson reviewed the experience of the consultants at the Clinic with this group of tumors. They found that the Pancoast syndrome was not a distinct clinical entity. Any lesion of the superior pulmonary sulcus which is adjacent to the brachial plexus or sympathetic chain may reproduce some or all of these symptoms. Neurofibromas or even inflammatory lesions of the lung situated at the apex of the thoracic cage may cause the symptom complex.

The pain associated with superior sulcus lesions is likely to be a severe shooting pain extending from the supraclavicular region to the finger tips. Muscle atrophy and Horner's syndrome frequently are later manifestations. A roentgenographic study of the thorax is certainly indicated whenever the cause of arm pain is obscure.

PAIN OF ESOPHAGEAL ORIGIN

Moersch and Miller have reviewed the subject of esophageal pain and have correlated the present knowledge of the innervation of the esophagus with clinical observations. They have considered the role

of the vagus, phrenic and sympathetic nerves in the cause of referred pain observed in certain types of esophageal lesions

Organic lesions of the esophagus, such as carcinoma or esophagitis, often cause pain, however, the pain of such lesions usually is localized in the substernal area. Patients are usually more accurate in localizing lesions of the upper part of the esophagus than they are in localizing lesions of the lower part of the esophagus. It is rather uncommon for lesions of the esophagus to give rise to referred pain.

Spasm of the esophagus is likely to produce pain that is referred into the neck and arms. Diffuse spasm of the esophagus is a clinical entity which is commonly confused with cardiospasm. Pain is the predominant symptom in four of five cases of diffuse spasm and the pain is commonly referred to the epigastrium and thoracic segment of the spinal column, to the neck, the jaws, the ears and sometimes to one arm or both arms. The pain of diffuse spasm is often produced by nervous tension. In cases of early cardiospasm, the pain may be of a colicky nature. In the advanced stage of cardiospasm, the greatly dilated esophagus seldom produces pain. Esophageal spasm may occur with foreign bodies or diverticulas and the pain may simulate the pain of diffuse spasm or cardiospasm.

PAIN OF DIAPHRAGMATIC ORIGIN

The phrenic nerves originate from the third, fourth and fifth cervical segments and pass through the thorax to innervate the diaphragm. Painful stimuli from the diaphragm apparently are carried by the phrenic nerves to the cervical segment of the spinal column where connections are made with nerves that make up the brachial plexus. Diaphragmatic lesions thus may cause pain in the arms. Such pain is referred along the radial rather than the ulnar aspect of the arm. Inasmuch as cardiac pain is referred to the ulnar aspect of the arm, theoretically one should be able to distinguish cardiac lesions from diaphragmatic lesions by the distribution of the arm pain. Unfortunately, the clinical distinction is often very difficult to make. The fact that pain of cardiac origin and that of esophageal origin have the same distribution when referred to the arm makes differential diagnosis even more difficult.

Lesions of the central portion of the diaphragm may be referred to the arm. Thus esophageal hiatal hernias are the commonest cause of arm pain of diaphragmatic origin. Lesions affecting the periphery of the diaphragm are more likely to give rise to intercostal pain. It must be remembered that diaphragmatic pleurisy also produces pain in the shoulder and arm. Postoperative pulmonary embolism most commonly causes diaphragmatic pleural pain. However, one must also think of subphrenic processes when arm pain occurs.

SUMMARY

Whenever arm pain occurs which has no obvious cause, inquiry should be made with reference to possible disease of the lungs, esophagus or diaphragm. Inasmuch as arm pain may be the initial or predominant symptom of such intrathoracic lesions, roentgenographic study of the thorax, esophagus and stomach is necessary if such conditions are to be excluded. Usually, associated symptoms or findings can be elicited which will confirm or deny the existence of thoracic disease.

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ARM PAIN DUE TO HEART DISEASE

HARRY L. SMITH

THE most common site of cardiac pain is in the anterior part of the thorax, under the sternum. Pain situated in this region usually is not considered as referred pain. Referred pain, resulting from heart disease, occurs more often in the arms than it does in any other part of the body. Cardiac pain that is referred to the arms is produced by a rather complicated mechanism. It is thought that the pain impulses begin in the nerve endings in the heart muscle. There are three cardiac plexuses, namely, a superficial plexus and two deep plexuses. The superficial cardiac plexus is situated in the concavity of the aortic arch, in front of the bifurcation of the left pulmonary artery. It has not been actually proved that this plexus transmits pain impulses. Each deep cardiac plexus is situated behind the aortic arch on either side of the trachea, just above its bifurcation. The pain impulses originate in the nerve endings and they pass upward through the cardiac plexuses and ascend through the middle and inferior cardiac nerves to their respective ganglia. From here, the impulses descend in the paravertebral sympathetic chain, they then pass through the white rami communicantes to the ganglia on the posterior roots of the spinal nerves. In the spinal cord, the impulses are carried by the lateral spinothalamic fasciculus on the opposite side. From here, they proceed to the cortex by way of the thalamus.

Just how pain that originates in the heart produces the impression that it comes from the arm is not clearly understood.¹ One of the most recent explanations of this phenomenon is that pain which originates in a visceral organ, such as the heart, and proceeds through certain segments of the spinal cord and ascends to higher centers in the brain is projected in space to a somatic structure, such as the arm, from which painful stimuli arise by employing the same segments of the spinal cord that are traversed by pain impulses coming from the viscera.

The most common cardiac diseases that produce pain in the arm are (1) coronary sclerosis associated with angina pectoris and (2) acute coronary occlusion. Occasionally, syphilitic aortitis which involves the coronary orifices will produce pain in the arms. Very rarely pericarditis and paroxysmal tachycardia will produce pain in the arms. Dissecting aneurysm of the thoracic aorta may rarely produce pain in the arms. The actual pain is supposed to be due to anoxia from ischemia of the cardiac muscle.

The pain that occurs in the arms in cases of heart disease is an

aching type of pain. Sometimes, patients will refer to it as a cramp-like pain. The pain in the arm usually occurs at the same time as the pain in the thorax. Often, the patient will describe the pain in the arm as though it extended upward and outward from the sternum to the shoulder and down the arm. The patients usually will feel or experience the thoracic pain and, at the same time, they will feel the pain in their arms. The pain may be felt in both arms, but it most frequently is in the left arm. The pain usually is felt on the inner side of the arm and extends downward as far as the elbow. It may be felt in the upper part of the arm. It usually stops at the elbow, but it may be felt in the wrist at the same time. As a rule, it is not a continuous pain all the way down the arm. Sometimes the pain will extend down to the finger tips. When the pain extends down to the fingers, the character of the pain often will change. Patients will describe the pain in the fingers as a burning and tingling sensation. The pain may involve all of the fingers, but it most frequently involves only the small and ring fingers. Sometimes the pain will start in the fingers and extend upward, but this occurs so rarely that, for practical purposes, it may be disregarded. Sometimes there are hyperesthesia and tenderness in these areas.

The most important character or feature of pain in the arms is that it must be produced by effort. It occurs during an effort and not afterward. Body effort, such as walking, lifting or shoveling, usually is required to produce the pain. As a rule, moving arms alone will not produce pain in the arms unless the heart disease is far advanced. The pain is produced by effort and relieved by rest. It may be precipitated by excitement and anger. The pain usually lasts from a half minute to two or three minutes but it may last twenty minutes. In the presence of coronary occlusion, the pain may last an hour or longer.

The pain in the arms that is associated with angina pectoris is relieved by rest and administration of glyceryl trinitrate. Relief usually occurs in two to five minutes. As a rule, the more severe the pain is in the arm, the more severe the heart disease. Severe pain in the arms in cases of coronary disease usually denotes a bad prognosis.

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PAIN IN THE UPPER EXTREMITY CAUSED BY PERIPHERAL VASCULAR DISEASE

NELSON W BARKER

PERIPHERAL vascular disease is an uncommon cause of pain in the upper extremity. In the differential diagnosis of the causes of pain in this part of the body, a relatively simple examination will suffice to exclude peripheral vascular diseases. The presence of any of the following findings may indicate peripheral vascular disease: swelling, discoloration, prominent superficial veins, ulceration or gangrene of the digits, absence of pulsation in the radial, ulnar or brachial arteries, palpable thrombosed veins, abnormal coldness or warmth of the skin, thrills, bruits, and pulsating masses. If none of these physical findings are present, it is almost certain that the pain is not caused by vascular disease.

SUDDEN ARTERIAL OCCLUSION

The pain of sudden arterial occlusion may be moderate or severe. It is usually diffuse throughout the hand and forearm and frequently is associated with a sensation of numbness. The onset may be abrupt or gradual during a few hours. The hand and forearm are cold and pale. The superficial veins are collapsed and the arterial pulsations are absent below the proximal point of occlusion. Hypesthesia or even anesthesia having a glove-like distribution may be present. Muscular weakness of the hand and forearm and even paralysis may occur.

Sudden arterial occlusion in the arm may result from embolism or from thrombosis in situ. In cases of embolic occlusion the embolism almost always comes from the heart and the patient has serious heart disease such as auricular fibrillation, myocardial infarction or subacute bacterial endocarditis. When the occlusion is thrombotic, the thrombosis may occur as a postoperative complication, as a result of severe blunt injury, as a complication of blood dyscrasia or congestive heart failure, or it may occur during the course of thromboangiitis obliterans. Acute arterial thrombosis in the upper extremity from other causes, including arteriosclerosis obliterans and idiopathic or essential thrombosis, is very rare.

CHRONIC OCCLUSIVE ARTERIAL DISEASE

When pain in the upper extremity is due to chronic ischemia the cause is usually obvious. The pain usually is situated in the digits and is frequently associated with trophic changes, ulceration or gangrene of the digits. Usually, it is less severe than the pain which is

present in the lower extremity as a result of this disease. The painful digits, if not ulcerated or gangrenous, are frequently red or cyanotic and they are almost always colder than the other digits. They usually blanch excessively on elevation. Pulsation in one or both of the arteries at the wrist usually but not invariably is absent.

Chronic occlusive arterial disease less frequently produces two other kinds of pain in the upper extremity. Intermittent claudication is a muscular distress which occurs only after a period of use of the muscles and is relieved promptly by rest of the muscles. Pulsations in the major arteries are almost always absent at palpable points proximal to the site of the claudication. Ischemic neuritis may occur after acute arterial occlusion or in chronic occlusive arterial disease if the subclavian or axillary arteries are occluded and pulseless. Ischemic neuritis may produce various types of paresthesia and severe paroxysmal pains of wide distribution. Reflexes are not commonly lost and complete paralysis is rare in cases of ischemic neuritis.

Thromboangitis obliterans is the only chronic occlusive arterial disease that commonly affects the upper extremity. Involvement by arteriosclerosis obliterans is rare. Occlusion of the arteries may be associated with cervical ribs and the scalenus syndrome. The arteries of the dominant hand may become occluded as the result of chronic occupational trauma.

RAYNAUD'S DISEASE AND ALLIED DISORDERS

Uncomplicated Raynaud's disease rarely produces pain. There may be some numbness and tingling during the phase of pallor or mild aching in the digits during the phase of rubor. The small trophic lesions of the finger tips which occasionally complicate Raynaud's disease may be painful. Several of the diseases which produce secondary Raynaud's phenomena may produce pain. Acroscleroderma (acrosclerosis) may cause severe pain in the digits and ulceration and gangrene similar to those seen in thromboangitis obliterans. It also may produce pain and stiffness in joints. The diagnosis of acroscleroderma is obvious from the thick, tight skin, particularly of the digits but often of the hands, arms and face as well. Cervical ribs and the scalenus anticus syndrome may produce Raynaud's phenomena and pain in the arm and hand, but the pain is not associated directly with the Raynaud's phenomena. It is caused by compression of the brachial plexus. If secondary arterial thrombosis occurs, there may be pain in the digits as a result of chronic ischemia. When pain occurs in cases in which Raynaud's disease is secondary to disease of the spinal cord or peripheral nerves, the pain is the result of the primary lesion and not of the vasomotor manifestations.

ERYTHROMELALGIA AND ALLIED DISORDERS

Erythromelalgia is a rare vasodilating disorder and a still rarer cause of pain in the upper extremity. The pain occurs in the affected part, digits or hand, and may be bilateral. It is episodal, of a burning type, and is always accompanied by increased objective heat of the skin of the affected part. Sudek's atrophy and some causalgic states may produce chronic vasodilatation and increased local heat. The vasodilatation may contribute to the pain but is not the primary cause of the pain.

ARTERIAL ANEURYSM

Arterial aneurysms of the upper extremity are usually of traumatic origin. They may cause local pain if they enlarge and press on nerves. They are easily recognized as pulsating tumors in the course of large arteries.

ARTERIOVENOUS FISTULA

Many arteriovenous fistulas both congenital and acquired are painless but they may produce two types of pain. One type is a diffuse aching, particularly after use of the extremities. This is the result of congestion. The other is a more constant pain in a cold, ulcerated or gangrenous digit. This is the result of ischemia since the blood may be shunted away from the capillary bed of one or more digits. Arteriovenous fistulas are almost the sole cause of dilated tortuous and varicose veins of the upper extremity and the dilated veins are obvious if there is sufficient congestion to produce pain. Thrills and bruits are constant manifestations of traumatic arteriovenous fistulas and are frequently present in cases of congenital arteriovenous fistula. The arm affected by congenital arteriovenous fistula is usually longer than the normal arm. If there are no dilated veins, no thrills or bruits and if the length of the arm is not increased, arteriovenous fistula can be excluded as a cause of pain.

ACUTE THROMBOPHLEBITIS

Acute thrombophlebitis may produce pain in the region of the affected vein. If the axillary or subclavian vein is affected, the thrombophlebitis may produce diffuse aching pain throughout the arm.

Thrombophlebitis of the median basilic or median cephalic vein is not uncommon after the injection of drugs or hypertonic solutions of any type. The affected vein may be painful and can be felt as a tender cord. There is usually some redness of the skin over it.

Thrombophlebitis of the superficial veins of the arm may occur in tender red cords in or just under normal visible superficial veins.

Acute axillary or subclavian thrombophlebitis produces both local and diffuse pain in the arm. It also produces enlargement (sometimes pitting edema), cyanosis of the skin and prominence of the superficial veins. The axillary vein can usually be felt as a tender cord. Axillary or subclavian thrombophlebitis may occur as a complication of surgical operations, severe injury, infectious diseases, congestive heart failure and blood dyscrasia. Occasionally, it develops in healthy adults after a mild strain of the abducted arm, which may be incurred during work or athletics.

CHRONIC VENOUS INSUFFICIENCY

Chronic venous insufficiency of the arm is rare. It may follow axillary or subclavian thrombophlebitis and usually occurs with arteriovenous fistula and occasionally with extensive hemangioma. A dull aching pain in the arm occurring particularly after sustained muscular effort and disappearing slowly after activity ceases, may be caused by chronic venous insufficiency. If it is sufficiently severe to produce this distress, chronic venous insufficiency may be recognized by prominence of superficial veins, increased venous pressure in the arm and diffuse enlargement of the arm.

ACUTE DIFFUSE LYMPHANGITIS

Acute diffuse lymphangitis of the arm may follow local injury or infection or may occur spontaneously at an interval after injury to or operations on the axilla, such as radical mastectomy. It may complicate diseases in which axillary lymphadenopathy occurs and it may complicate lymphedema due to any cause. Acute diffuse lymphangitis usually causes moderate to severe diffuse pain. Other manifestations are diffuse redness, swelling and increased heat in the arm, and chills, fever and malaise.

CHRONIC LYMPHEDEMA

Chronic lymphedema may produce some heaviness in the arm but does not often cause pain. The diagnosis is obvious from the enlargement and brawny induration without evidence of venous congestion.

SUMMARY

Peripheral vascular disease is a relatively uncommon cause of pain in the upper extremity. When it is the cause of such pain, a comparatively simple examination will quickly reveal the manifestations of the vascular disease.

NEUROLOGIC CAUSES OF PAIN IN THE UPPER EXTREMITIES

With Particular Reference to Syndromes of Protruded Intervertebral Disk in the Cervical Region and Mechanical Compression of the Brachial Plexus

L M EATON

INTRODUCTION

THE importance of neurologic lesions that produce pain in the upper extremities lies not in their frequency but in their accounting for a considerable number of those pains that are most severe, most protracted and most amenable to treatment. This is particularly true since the realization that some of the severest pains result from protrusions of intervertebral disks in the cervical region. Often the pain resulting from these lesions is attributed erroneously to hypertrophic arthritis of the cervical portion of the spinal column, neuritis of the brachial plexus, cervical radiculitis or compression of the brachial plexus by the anterior scalenus muscle. With these facts in mind, I shall devote the major portion of the discussion to those lesions which occur most commonly and for which treatment is available, namely, mechanical pressure on the brachial plexus and protrusions of cervical disks. Lesions which are encountered less frequently or are less responsive to treatment will be discussed more briefly.

Before I proceed to a discussion of the specific lesions, it may be of value for me to call attention to the difficulty in differential diagnosis between neurologic lesions in general and non neurologic lesions which give rise to referred pain. Pain from viscera or deep lying somatic structures such as muscles, joints or ligaments tends to be referred segmentally, just as pain arising from disease of a nerve root or nerve is projected into the segment supplied by the affected fibers far beyond the site of the lesion. For example, a lesion in a deep lying somatic structure, such as the ligament between the spines of the sixth and seventh cervical vertebrae, may produce pain referred to approximately the same area as that in which pain can be caused by compression of the seventh cervical nerve root by protrusion of the intervertebral disk between the sixth and seventh cervical vertebrae. Lewis pointed out that somatic and visceral lesions may, in addition to pain, give rise to muscle spasm, deep tenderness, hyperalgesia and definite paresthesia. Although this investigator found that definite paresthesias of numbness and tingling resulted from experimental lesions of somatic structures and viscera, I think it advisable to point

out that these sensory phenomena seldom are encountered clinically. Well-developed paresthesias should direct the diagnostic efforts first toward a search for lesions directly involving the peripheral or central nervous system.

LESIONS OF THE CENTRAL NERVOUS SYSTEM

Intramedullary lesions of the central nervous system which are relatively uncommon, may give rise to pain in the upper extremities. When they do, the pain usually is the result of involvement of the sensory pathways in the cervical portion of the spinal cord, the brain stem or the thalamus. The fact that the pain arising from involvement of the sensory tracts tends to spread beyond the confines of the upper extremity to the trunk and even to the lower extremity on the same side gives a clue as to the central site of the lesion producing it. The situation is sooner or later clarified by such observations as dissociated anesthesia—for example, the loss of pain and temperature sensation but preservation of tactile sense—and by signs indicative of involvement of the pyramidal tract and so on, which attest to the presence of a lesion in the substance of the central nervous system. Syringomyelia and intramedullary tumor of the spinal cord are common examples of intramedullary lesions that may give rise to pain in the upper extremity.

LESIONS OF THE NERVE ROOTS

Miscellaneous—Of greater importance from the standpoint of frequency of occurrence are intraspinal lesions that produce pain by pressure on, by invasion of or by other types of involvement of, the sensory nerve roots. Rheumatoid spondylitis, protruded intervertebral disks, extramedullary tumors of the spinal cord, all of which may occur in the cervical region, are among the causes of root pain. Fortunately, root pain has characteristics which serve to distinguish it from other types of pain and thereby direct attention to the site of the lesion at the intervertebral foramen or along the nerve root, intraspinally.

Three characteristics of root pain are of greatest value in differential diagnosis. The first is the distribution of pain within the segment supplied by a particular nerve root. The second is the frequency with which the pain is intensified by coughing, sneezing and straining such as occurs in lifting, defecating, voiding, laughing and blowing the nose. The author has presented evidence to show that, in most cases, this effect is not due to an increase in intraspinal pressure per se, but rather, that it results from increased intrathoracic and intra-abdominal pressure blocking the flow from the intervertebral veins. Engorgement of the veins in the epidural spaces thus occurs, and this in turn either produces pressure on the nerve root directly or stretches the root by displacing the dura toward the spinal cord.

The third most valuable characteristic in diagnosis is the intensifica-

tion of the root pain which is brought about by other means of stretching the involved nerve roots. That is to say, the roots may be stretched by movements of the spinal column by downward traction of the arm when roots in the cervical region are involved and by the Lasègue maneuver when lesions involving the lumbar plexus are present.

Furthermore I believe that a patient's root pain is intensified at night after several hours in the horizontal position, and that it is alleviated by resumption of the upright position as a result of stretching and relaxing of the nerve roots. Stretching of the nerve roots most often results from the fact that the spinal column elongates while one is in the horizontal position whereas the nervous elements within the column do not elongate concomitantly.

Extramedullary tumors such as neurofibromas, situated where they are likely to involve roots of the fifth cervical to the second thoracic nerves frequently give rise to pain in the upper extremity long before other signs and symptoms have appeared. Palpation of a mass at an appropriate intervertebral foramen in the cervical region or roentgenographic evidence of an enlarged foramen, may give evidence of a dumb bell shaped neurofibroma. Intraspinal neurofibromas and other extramedullary tumors may be revealed by roentgen ray evidence of eroded vertebral pedicles or bodies by the increased content of protein in the cerebrospinal fluid and later by the findings of compression of the spinal cord (dynamic block (manifested by positive result of Queckenstedt test) at lumbar puncture, and by visualization of a lesion in the subarachnoid space when roentgenoscopy is carried out after the introduction of contrast media.

Metastatic tumor which involves the nerve roots is suggested by the rapidity of progression, and can be distinguished by the history or the finding of primary malignancy elsewhere and by other evidence of metastasis such as is found in roentgenograms of the thorax and spinal column.

Inflammatory lesions are likely to involve several nerve roots simultaneously and to be associated with inflammatory processes outside the central nervous system. Thus nonspecific epidural abscess frequently follows a boil or other extraspinal infectious process and manifests itself by severe bilateral root pain followed by signs of dysfunction of the spinal cord. The cell content of the spinal fluid and a dynamic block develops before or as signs of meningitis may be present on lumbar puncture.

Tuberculous lesions which produce root pain are suggested by the history and by the fact that they are common to tuberculosis and are associated with lesions of the spine.

Traumatic spinal lesions, such as fracture dislocations which at times produce root pain, are readily detected roentgenographically and are suggested by the history and signs of dysfunction of the spinal cord at the appropriate level

Protruded Intervertebral Disk.—One of the most common and most important causes of root pain in the upper extremity is protrusion of intervertebral disks in the cervical region Today, the status of this particular problem is somewhat analogous to that of protruded disks in the lumbar region a decade ago At that time, the cause of the clinical picture produced by protrusion of disks in the lumbar area was not generally recognized Often it was erroneously attributed to a host of what were at best merely academic possibilities Today, a sufficient number of carefully studied cases of, and successfully treated patients with, protruded disk in the cervical region have been recorded so that the characteristic clinical picture can be described with some degree of accuracy

As experience with protrusions in the cervical region accumulates atypical pictures undoubtedly will be encountered and there is danger that enthusiasts will tend to explain, on this basis, all pain in the upper extremities for which no obvious explanation exists It will become increasingly important that the surgeon give unbiased consideration to each case and a thorough trial of conservative treatment before resorting to surgical exploration

Protruded disks in the cervical region occur less frequently than those in the lumbar region but they are not so rare as was believed a few years ago The earliest cases described tended to be those in which the protrusions were largest and produced the most obvious objective signs of neurologic disease Thus, chondromas have now been recognized as being protruded disks The earlier cases verified surgically at the Mayo Clinic were characterized by a predominance of symptoms and signs of compression of the spinal cord, whereas analysis of those cases in which surgical intervention has been carried out during the last few years shows only a few such symptoms and signs In the majority of recently verified cases the subjective symptoms of pain and paresthesia dominate the clinical picture and the objective signs of compression of the spinal cord and injury to nerve roots are relatively infrequent

This same tendency is reflected in reports from other parts of the country For instance, the cases reported by Stookey in 1928 were characterized by compression of the spinal cord, whereas in the later reports of Semmes and Murphey and Michelsen and Mixter the symptoms and signs were predominantly those of root compression

First let us reconstruct the clinical features of protruded intervertebral disks in the cervical region as described by Semmes and Murphey Michelsen and Mixter, Bucy and Chenault and Elliott and

compression test in which the patient's neck is flexed laterally toward the affected side while downward pressure is exerted on the forehead from behind is the maneuver most likely to aggravate pain when the condition is acute. Semmes and Murphey found a point of exquisite tenderness over the site of exit of the affected nerve root from the spinal canal. It is pointed out that at times the pain may be alleviated by cranial traction, immobilization of the neck, tilting of the head to one side or the other, usually away from the affected side, carrying of the arm in a position of hyperabduction (laterally abducted to an elevated position) and sleeping on an extra pillow.

The objective findings which will be made on neurologic examination are determined largely by the duration and degree of the compression, the level of the protrusion and most importantly by the position of the protrusion in a transverse direction. Objective findings often are lacking when a protrusion of short duration is placed far laterally so that only the root is compressed. On the other hand a large midline protrusion which presses on the ventral surface of the spinal cord may produce an incomplete transverse lesion with profound motor and sensory paralysis below the affected level. A protruded disk which presses lightly on the ventrolateral portion of the cord may cause only a loss of the abdominal reflexes or a slight increase in the muscle reflexes with or without the presence of the Babinski sign on the affected side.

The most common objective finding is some degree of loss of pain, sense of temperature and tactile perception in the fingers and less commonly in the hand and forearm. Slight atrophy and weakness of the triceps brachii muscles and decrease of the triceps reflex are not uncommon. The deltoid may exhibit some degree of atrophy particularly in compression of the sixth root and when the eighth is compressed there may be atrophy in the small muscles of the hand. Muscular twitches occur but are uncommon.

There has been no particular emphasis on the diagnostic importance of plain roentgenograms of the cervical part of the spinal column since they may give negative results or show only minimal hypertrophic changes. It has not been uncommon to find narrowed interspaces in such roentgenograms but *loss of normal cervical lordosis has been the most consistent abnormality detected*. The results of roentgenoscopy with iodized poppy seed oil have been disappointing except when the largest disks have compressed the spinal cord. Elliott and Kremer favored the use of ethyl iodophenylundecylate (pantopaque). With it they demonstrated to their satisfaction the protruded disk in all three of the cases in which it was used. Attention is called to the fact that in their eight reported cases none of the patients was treated surgically. Consequently the diagnoses of the authors are unverified.

TABLE 1—GENERAL DATA, DISTRIBUTION OF SENSORY PHENOMENA AND PROTEIN CONTENT OF CEREBROSPINAL FLUID.
NINE MALE PATIENTS WITH THE CERVICAL DISK SYNDROME

General Data										Distribution of Sensory Phenomena (Pain and Paresthesia)					
Case	Root Compressed	Pain Side (Right or Left)	Age at Time of Operation	Duration of Symptoms	Intermittent Course	Shoulder Girdle				Arm		Forearm		Digits	
						Low Cervical Region	Intercapular Region	Scapular Region	Pectoral Region	Dorsolateral Aspect	Medial Aspect	Radial Aspect	Ulnar Aspect		
1	C6	L	45	4 mos	0	+		+				+		1	
2	C6 and C7	L	53	3 yrs	+			+		+			+	1 2 3 4	
3	C7	I	46	5 mos	0			+		+		+		1 2 3	
4	C7	L	44	2 yrs	0	+		+		+		+		1 2	
5	C7	R	32	3 mos	+	+		+						Not specified	
6	C7	L	42	5 mos	+		+							2 3	
7	C8	I	67	15 da	0	+	+	+			+		+	4 5	
8	C8	L	44	2 yrs	+			+		+	+	+	+	4 5	
9	C8	R	45	2 yrs 9 mos	+		+	+	+		+		+	5	

* Result of Queckenstedt test was negative in all cases

† Pain extended through entire upper extremity to fingers but exact distribution was not described

‡ Lumbar puncture was not performed in case 7

Observations made at lumbar puncture have ranged from dynamic subarachnoid block, with moderate elevation of total protein content in cases of large protruded disks which have compressed the spinal cord, to discovery of a normal state in many cases. Slight to moderate elevation of the total protein content was noted in five of eight cases reported by Michelsen and Mixer, as well as in two of four cases reported by Semmes and Murphey.

Serious trauma to the neck has not been found to be an essential precursor to the cervical disk syndrome. Often very minor movements, such as a quick turn of the head, have precipitated the symptoms, and yet a considerable number of patients have reported that a significant injury to the neck occurred many years before the onset of the complaints for which they sought relief. An intermittent course extending over many years, has been commonly described. Some patients have complained of cricks in the neck, such as are often attributed to sleeping in a draft.

Analysis of Nine Cases—As an additional check on the syndrome produced by the protrusion of intervertebral disks in the cervical region I have selected nine cases from the series of the Mayo Clinic for detailed analysis. All these have been verified surgically by Dr J G Love and Dr A W Adson. For the most part, the cases were collected at random, but cases in which compression of the spinal cord was a prominent feature, and those in which the level of the protrusion was not determined unequivocally, were excluded. Neurologic examination in these cases was performed by Drs H W Woltman, F P Moersch, P H Heersema and the author. For the sake of brevity, the analysis has been tabulated and summarized (table 1). I shall add a few remarks which are considered pertinent to the problem.

COMMENT ON CASES IN TABLE 1—A review of table 1 shows that all the patients were men between the ages of 32 and 67 years, and that only two of the

neck sustained six months before the onset of pain characteristic of the lesion was almost certainly a factor in one case and in three others in which the injury preceded the onset of symptoms by three to fifteen years it cannot be dismissed as a causative factor. In three cases the symptoms were initiated by lifting and in three others by sudden movement of the head. It may be significant that one patient gave a history of previous low back pain and sciatic pain suggestive of a protruded disk in the lumbar region.

Attention is called to the fact that pain was the chief complaint in all cases and that paresthesia consisting of numbness, tingling and prickling was well developed in all but two cases.

The first symptom in three cases was pain localized to the lower part of the cervical region. In two others the first symptom was pain in the upper interscap-

ular region, and in another case it was pain over the upper part of the scapula. In one case pain began in the supraclavicular region. In another case the pain manifested itself while the patient was massaging his scalp, and was sensed as a stabbing pain from the lower cervical region, extending through the scapular region into the arm. In case 1 the onset consisted of a tingling sensation in the thumb as the patient made a quick turn of the head.

The distribution of sensory phenomena, when these are well developed, clearly distinguishes compression of the eighth cervical nerve root from that of the sixth and seventh roots but distinction between compression of the sixth and seventh roots cannot always be made on this basis. Furthermore, more than one disk may be protruded (case 2), consequently, it would seem advisable to explore both the sixth and seventh nerve roots in cases in which a protruded disk has been diagnosed at the level of either of these roots by clinical study.

There is nothing unusual about the factors found to aggravate or alleviate the pain in our cases, with the possible exception of the tendency for a long trip by automobile to be followed by exacerbation of the patient's symptoms. Dr. Woltman called our attention to this feature, and I predict that it will be found an aggravating factor of frequent occurrence if specific inquiry regarding this point is made. Coughing, sneezing or straining aggravated the symptoms of seven patients. Movements of the neck intensified the pain of eight patients. Three patients specified that bending the neck backward, as in shaving under the chin, made the pain worse. In one case, lateral flexion of the neck toward the affected side, and in another, forward flexion of the neck, were the specific motions most likely to aggravate the pain. Lateral flexion of the neck away from the affected side can be expected to intensify the pain if the shoulder on the affected side is maintained in a depressed position. This maneuver results in the exertion of traction on the nerve roots, and is analogous to the traction produced on the lumbar roots by the straight leg raising test.

Few objective findings were made on neurologic examination of the nine patients in this group. Results of examination of four patients were entirely negative. Subjective decrease in the perception of touch, pain and temperature on the digits and hand was not unusual but in no case was anesthesia unequivocally present. In three cases there were slight weakness and atrophy of the triceps muscle, with decrease of the reflex. In one of these three cases there were slight weakness and atrophy of the triceps and scapular muscles, muscular twitches in the same muscles and in those of the radial aspect of the forearm, hyperactive muscle reflexes in the lower extremity, and a perceptible Babinski sign on the affected side.

Since the triceps muscle receives its chief innervation from the seventh and eighth cervical nerves, some degree of weakness, atrophy, loss of muscle stretch reflex, and possibly muscle twitching, can be expected to appear in this muscle when a protruded disk compresses the seventh or eighth cervical nerve root. The deltoid, biceps brachii and brachioradialis muscles are supplied by the fifth and sixth cervical nerves and, consequently, disks which compress the sixth cervical nerve root are likely to cause the same changes in these muscles. Disks compressing the fifth nerve root may affect the same group and, in addition, the supraspinatus and infraspinatus muscles.

There was little to be found in this group of cases by lumbar puncture. It was performed in eight cases, and the results were entirely negative, except for one instance (case 6) in which the total protein content of the cerebrospinal fluid was slightly elevated.

Dr. C. A. Good studied the plain roentgenograms of the cervical part of the spinal columns of these nine patients and found that only two patients had normal cervical lordosis. The spinal columns of four patients were straight through-

out the normal curve of the spinal column of another patient was even reversed. The upper part of the cervical region of two other patients showed about the normal degree of curvature, but the lower three vertebrae either were straight or actually showed slight kyphosis. The point of maximal kyphosis exactly corresponded to the involved nerve root in only one case. In another case it was centered one interspace above the actual site of the lesion. In still another case it was centered one interspace below.

In four of the nine cases there was slight to moderate narrowing of the interspaces at which the protruded disk was found. In one of these four cases there was also narrowing of two other interspaces. In four other cases, none of the interspaces was narrowed. In the remaining case there was moderate narrowing of the anterior portion of the interspace below the level of the protrusion.

Hypertrophic changes were present in slight degree in four of the nine cases, in moderate degree in two and in marked degree in one case. Such changes usually occurred at the interspace at which the protrusion was found but this was not always true. These changes often occurred elsewhere in the spinal column too. Oblique roentgenographic views were obtained in four of the nine cases. In the two cases in which the roentgenograms showed that narrowing of the intervertebral foramina caused by hypertrophic changes had occurred the appropriate foramina were involved but in one case two foramina on the unaffected side were equally encroached on.

Roentgenoscopy after the introduction of iodized poppy seed oil was performed in only two cases. In both instances evidence of the lesion was disclosed by the procedure.

LESIONS OF THE BRACHIAL PLEXUS

Syndromes of Mechanical Compression of the Brachial Plexus
—In spite of the fact that the various syndromes of pressure on the brachial plexus have been discussed extensively in the literature, I fear that a great deal of confusion regarding this condition continues to exist. It is attested to by the fact that in case 4 of table 1 anterior scalenotomy had been performed before the patient came to the Clinic. Although there should be no difficulty in distinction between a clear cut case of protruded intervertebral disk in the cervical region and a clear cut case of the so-called scalenus syndrome the fact that the clinical picture is not always well developed, particularly early in the course of the disability, makes for no end of difficulty.

Furthermore, distinction of the various mechanical factors that lead to compression of the brachial plexus often is difficult except in the case of a well developed cervical rib. Yet in the great majority of cases, a cervical rib is not present. It is in the latter group of cases that greatest confusion seems to exist and it is my impression that the confusion is the result of (1) failure to consider all the mechanical factors known to result in compression of or pressure on the plexus and (2) too great dependence at diagnosis and in decision as to whether or not surgical intervention is advisable, on clinical tests for obliteration of the radial pulse.

In the first place many of the diagnostic maneuvers used rather generally do not distinguish between what is normal (physiologic)

and what is abnormal (pathologic) Furthermore, they do not give reliable information as to the exact site of compression Before I develop this theme further, it is advisable to consider the specific mechanisms known to lead to compression of, or pressure on, the brachial plexus

Cervical Rib Syndrome—The syndrome produced by cervical rib is well established The condition occurs in women approximately twice as frequently as in men, and produces pain in the right arm more frequently than in the left, although symptoms which occur bilaterally are common In a recent series of 7,706 stereoscopic roentgenograms of the thorax, at the Clinic, the presence of one or more cervical ribs was observed in forty five cases In twenty nine cases the patients were women

Almost always the patient seeks relief from pain and paresthesia of the upper extremity The patient most often complains of a dragging sensation through the shoulders and pain distributed over the deltoid area to the elbow When the condition is more severe, pain and paresthesia occur in the ulnar aspect of the forearm and hand, and in the fourth and fifth digits At times, it spreads to the radial aspect of the forearm, hand and digits, and to the neck, scapular and pectoral regions Sometimes, the patient may complain of pain in the head and face on the same side

There is a decided tendency for the symptoms to become worse at night while the patient is lying down At this time paresthesia may be particularly intense and may involve the whole upper extremity The patient may be awakened several times and find relief by lying prone and swinging the arm over the side of the bed However, when the syndrome is well developed, symptoms also occur at other times They may be aggravated by the use of the arms and particularly by use which depresses the shoulder girdle, such as the carrying of heavy objects or the maintenance for long periods of the position of the arms required in holding a book to be read On examination, it usually is found that the symptoms can be intensified by depressing the patient's shoulder

Alleviation of pain and distress often is found by the patient's elevating the shoulders, as in leaning forward on the elbows and by lateral flexion of the neck toward the affected side, a position that tends to relax the brachial plexus as well as the anterior scalenus muscle

As a rule, the pain of protruded disk in the cervical region during periods of exacerbation is much more intense than that produced by cervical rib Often, in the former instance, opiates are required for relief Furthermore, when a disk has protruded the pain is likely to be more abrupt in onset, more narrow in distribution, and the alleviating factors less effective, than in the syndrome of cervical rib and allied disturbances I believe that in many cases the effect of cranial

protruded intervertebral disk, the nervous tension, or whatever primary factors exist. Perhaps, rarely, such as in exceptionally well muscled persons, the anterior scalenus muscle may attain sufficient size to compress the brachial plexus and subclavian artery. In any event, there is need for careful re-evaluation of this syndrome.

Subcoracoid Pectoralis Minor Syndrome—It is now logical to introduce the subject of mechanisms other than those responsible for the cervical rib or scalenus syndrome, since these mechanisms produce clinical pictures and vascular signs often erroneously diagnosed as scalenus syndrome.

Wright, observing a patient who had gangrene of the finger tips resulting from sleeping with his arms elevated over his head in a hyperabducted position, was stimulated to study of neurovascular disturbances in the upper extremity. He called attention to the fact that among many people paresthesia develops in the upper extremities while the victims are sleeping with their arms over the head or are working with the arms hyperabducted, as in painting a ceiling. In a study of 150 normal subjects, Wright found that the radial pulse of 125 could be obliterated on the right side, and that the radial pulse of 124 could be obliterated on the left, by hyperabduction.

On the basis of studies with the cadaver, Wright found that at the region of transition between the subclavian and axillary artery, this vessel, the accompanying subclavian axillary vein and the brachial plexus were compressed beneath the coracoid process of the scapula by the stretched pectoralis minor muscle when the arm was hyperabducted. He designated this mechanism the "subcoracoid pectoralis minor syndrome" (fig 327, *a* and *b*).

Costoclavicular Syndrome—Falconer and Weddell have called attention to the fact that compression of the subclavian artery and vein and the brachial plexus may take place between a normal first rib and the clavicle. The mechanism of this syndrome is represented in figure 328, *a* and *b*. The interest of Falconer and Weddell was aroused by the first of four cases they reported to which they had made an erroneous diagnosis of scalenus syndrome. Their patient gave a history compatible with such a diagnosis, and it was found that hyperextension of the neck and posterior abduction of the shoulders—both being maneuvers which have been advocated as of value in the diagnosis of the scalenus syndrome—obliterated the radial and ulnar pulses on the affected side. However, it was found that the same maneuvers produced the same effect after the anterior scalenus muscle had been sectioned. This observation at the time of surgical intervention led to further investigation. Falconer and Weddell discovered a slight fusiform dilatation of the subclavian artery distal to the lateral edge of the anterior scalenus muscle, showing that the point of obstruction was lateral to the anterior scalenus muscle. Next, they found that

hyperextension of the patient's neck, by elevating the first rib, narrowed the space between the first rib and the clavicle. Posterior ab-

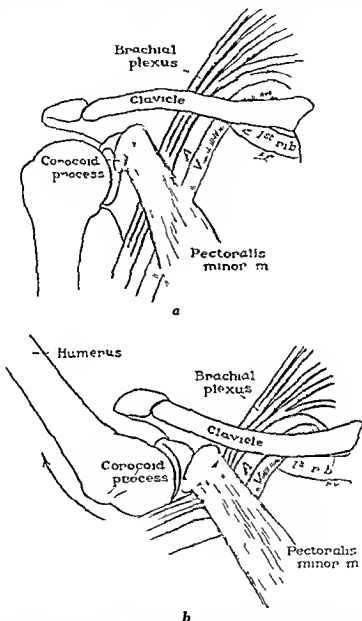


Fig 327—Schematic representation, on the basis of photographs by Wright, of the mechanism of the subcoracoid pectoralis minor syndrome. In *a* the patient's right arm is represented as being at the side, dependent. In *b* the arm is hyperabducted, laterally abducted to an elevated position. With the arm in this position it is seen that the brachial plexus and the accompanying vessels are compressed by tension of the pectoralis minor muscle.

duction of the shoulder likewise narrowed this space by moving the clavicle toward the rib. Being satisfied that the symptoms of their pa-

tient resulted from compression of the subclavian vessels and the brachial plexus in the costoclavicular space (fig 328, b), they resected 2.5 cm of the first thoracic rib at the point of compression. After resection of this rib, the patient's neck could be hyperextended and the shoulder pushed down and back without affecting the pulse of the extremity. Furthermore, the patient was relieved of symptoms. It seems certain that he would not have been relieved thus had the operation stopped with section of the anterior scalenus muscle. In two other similar cases, it was found that faradic stimulation of the anterior scalenus muscle to contraction had no effect on the pulse of the extremity although the patient's bracing the shoulders backward and

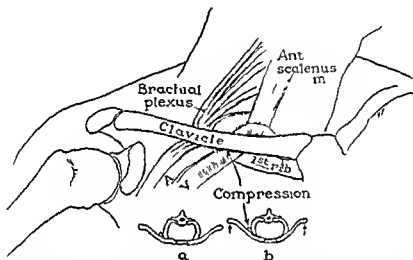


Fig 328—Schematic representation of the mechanism of the costoclavicular syndrome of Falconer and Weddell. In the inset, *a* the subclavian artery and vein and the brachial plexus are seen in their normal position between the first rib and the clavicle. In *b* downward and backward bracing of the shoulders has resulted in compression of these nerves and vessels.

downward caused obliteration of the pulse. It was also noticed that the latter maneuver produced engorgement of the superficial veins of the affected extremity and the chest. It was pointed out that asymmetry of the thoracic inlet or deformity of the clavicle might predispose to costoclavicular compression, and that the pulse in the arms of many normal persons could be reduced by bracing the shoulders backward.

First Thoracic Rib Syndrome—Falconer and Weddell reported a fourth case in which costoclavicular compression was not a factor in the production of symptoms. In this case pain, anesthesia and atrophy resulted from compression of the lower trunk of the brachial plexus

against the first rib by a taut, tendinous band which extended downward from the transverse process of the seventh cervical vertebra and was inserted in the inner border of the first rib between the subclavian artery and the first thoracic nerve root. Division of the tendinous band was followed by clinical cure. In this case, section of the anterior scalenus muscle would have resulted in failure.

In the older literature there is considerable discussion of compression of the brachial plexus by a normal first rib. Stopford and Telford reported on ten patients encountered within a period of two years. They pointed out that the clinical picture was that of the cervical rib syndrome and that embryologic and developmental factors might predispose to the condition. The embryologic variation of the post fixed plexus, in which there is a larger contribution from the second thoracic root, may, they thought, combine with the developmental factor of gradual descent of the shoulders from a high position in children to the lower position of the shoulders of adults, thus to draw the lower trunk of the brachial plexus tautly over the sharp edge of a normal first rib. Anything producing more than average descent of the shoulders might accentuate the situation and precipitate symptoms. Thus, fractures of the shoulder girdle, weakness of the muscles which elevate the shoulder girdle, whether this weakness is the result of specific lesions to nerves or general debility, and depression of the shoulders, such as results from the carrying of heavy weights or even the wearing of a heavy coat, may precipitate symptoms in this syndrome, as well as those in the case of cervical rib.

Comment on Mechanical Factors, Excluding Traumatic, Which Compress the Brachial Plexus.—What do we learn from these observations? We learn that the brachial plexus is known to be affected mechanically at times by cervical ribs, tendinous bands, the anterior scalenus muscles, the normal first rib, compression of the plexus between the normal first rib and the clavicle, and compression between the coracoid process of the scapula and the stretched pectoralis minor muscle when the patient's arm is hyperabducted. The subclavian artery can be compressed in all these situations. The subclavian vein, too, can be similarly affected in all cases except those of the scalenus syndrome, since the subclavian vein lies anterior to the anterior scalenus muscle and is separated by it from the subclavian artery and brachial plexus (fig. 328).

We learn that the maneuvers advised for testing for cervical rib and the scalenus syndrome are unreliable. For example, favorite tests include hyperextension of the patient's neck, turning the head toward or away from the affected side, and deep inspiration. Both deep inspiration and hyperextension of the neck elevate the first rib and may cause compression of the brachial plexus between it and the clavicle, or, if the patient's shoulder is maintained in a depressed position, in

spiration and hyperextension may draw the artery and brachial plexus more tautly over the first thoracic rib. If, to this test, is added hyperabduction of the patient's arm, another source of error is added, since compression of the vessel may take place between the coracoid process and the pectoralis minor muscle. Perhaps turning of the patient's head toward the affected side, so as to tighten the anterior scalenus muscle while the shoulder is supported in an elevated and anterior position without abduction of the arm, would be a more reliable test for the scaleous syndrome. If the radial pulse is obliterated in this position, it would almost certainly be the result of compression by the anterior scalenus muscle. Intensification of pain with this maneuver might occur in the presence of arthritis and protruded intervertebral disk in the cervical region.

Since the patient's bracing the shoulders backward and downward may obliterate the pulses in an extremity, and produce dilatation of the superficial veins over the arm and chest of the normal person, this maneuver is not a reliable test for the costoclavicular syndrome.

If the presenting symptoms pertain to thrombosis of the subclavian vein, I see no reason to suspect that the thrombosis results from compression of the vein by the anterior scalenus muscle. In that type of case, if the thrombosis is the result of compression, the point of compression should be found, rather, at the first rib.

I would summarize the situation in this way. The diagnosis can be obvious only in the presence of a well developed cervical rib which is palpable in the supraclavicular fossa or is demonstrable by roentgen rays, and is associated with symptoms or neurologic signs compatible with compression of the brachial plexus or with vascular obstruction. Consequently, in those cases in which symptoms are severe enough to warrant surgical intervention after the failure of conservative measures, great dependence must be placed on the surgeon, who would do well to consider all other possible factors at time of operation and to carry out those procedures necessary to alleviation. Thus, section of the anterior scaleous muscle without removal of the cervical rib may be all that is necessary, as has been demonstrated by Adson and Coffey. In other cases it may be necessary to cut tendinous bands (fig 329, *a*, *b* and *c*) or to remove portions of a cervical rib in addition to cutting the anterior scalenus muscle. In still others it may be demonstrated at operation that there is no need to cut the anterior scalenus muscle, and that, rather, resection of a portion of the first thoracic rib is indicated.

Nocturnal Dysesthesia—Before I leave the subject of compression of the brachial plexus, it is well to consider briefly the problem of nocturnal dysesthesia of the arm. Often, types of this syndrome are catalogued under the label of "idiopathic acroparesthesias." These are benign afflictions which appear as a rule among women after the age

of forty years. They are characterized by pain, paresthesia and, often, by a sense of stiffness in the hands and upper extremities after several hours in the recumbent position. The sensory phenomena disappear promptly after the arms are moved about. The course usually is intermittent and prolonged. Objective signs of neurologic and vascular diseases fail to develop even after many years. Wartenberg described a particular type of nocturnal dysesthesia characterized by sensory symptoms limited to the distribution of the ulnar nerve and he designated it as "brachialgia statica paresthetica."

Traumatic Lesions.—In addition to mechanical factors which compress the brachial plexus, other lesions of the plexus will result in pain in the upper extremities. Of these, traumatic lesions are most numerous. The most frequently occurring injuries to the brachial plexus re-

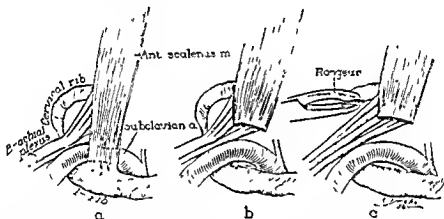


Fig. 329.—*a*, Schematic representation of pressure exerted on the subclavian artery and the brachial plexus by the anterior scalenus muscle and by a tendinous band extending from the tip of a cervical rib to the first thoracic rib; *b*, relief of pressure on the subclavian artery by section of the anterior scalenus muscle; *c*, relief of pressure on the brachial plexus by removal of a tendinous band and the tip of the cervical rib.

sult from penetrating and lacerating wounds, and from accidents which suddenly depress the victim's shoulder, such as a fall forward on the shoulder from a rapidly moving vehicle, or a sudden tug to the upper extremity, such as when it is caught in a rapidly moving belt or when the victim's hand grasps a support while he is falling from a height. The diagnosis is not difficult in these cases, since the history and neurologic observations of weakness, atrophy, decreased muscle reflexes, and anesthesia not limited to the supply of any one nerve, are sufficient to point to the brachial plexus or its roots as the site of dysfunction.

Tumors.—Tumors of the brachial plexus, and particularly metastatic or invasive tumors, are of importance. It is not infrequent for carcinoma of the breast, after apparently successful surgical treatment,

to manifest itself by pain caused by metastasis to the brachial plexus. In this instance the history, the relentless course, and the finding of induration in the supraclavicular area are diagnostic. In every case of severe pain of relatively short duration in the upper extremity for which the explanation is not obvious tumor of the pulmonary sulcus (Pancoast's tumor) should be considered. Particularly is this true if Horner's syndrome is an associated observation. In more advanced stages definite induration may be palpated deep in the supraclavicular fossa but usually it is necessary to depend on roentgenographic evidence of the tumor for the reaching of an absolute diagnosis.

Benign tumors such as neurofibromas may be found to account for pain in the upper extremity. The diagnosis depends on palpation of the tumor at an intervertebral foramen or in the brachial plexus or the nerves emerging therefrom. The finding of multiple neurofibromatosis (Recklinghausen's disease) elsewhere may make the diagnosis certain. Otherwise the nature of the lesion will be determined by the results of surgical exploration and biopsy.

Inflammatory Lesions—Inflammatory lesions of the brachial plexus are much less common than was once believed. In the past the term "brachial plexus neuritis" has been applied much too freely. I feel certain that in many cases a condition so designated in reality was protruded intervertebral disk in the cervical region. In many cases too severe bursitis, tenosynovitis and the like, particularly if the pain was referred segmentally, must have been mistaken for brachial plexus neuritis. Of course in rare instances true inflammatory lesions occur which are localized to the brachial plexus. Suppurative processes in the supraclavicular area may involve the brachial plexus but as a rule inflammatory lesions of this plexus are parts of widely disseminated neuritis such as occurs in the various kinds of polyneuritis.

Serum Paralysis—According to Woltman serum paralysis most often results from a reaction in the brachial plexus but the lesions may occur in other parts of the peripheral and central nervous system. The symptoms occur on an average, two days after the onset of serum sickness. The interval between the injection of the foreign serum and the development of serum sickness averages seven days. Since the upper part of the brachial plexus is most often involved the pain extends through the shoulder girdle and lateral part of the arm in the area supplied by the fifth and sixth cervical nerves. Sensory loss which occurs in approximately a fourth of cases is most often found in the same dermatomes. The deltoid, biceps brachii, brachioradialis and other muscles supplied by the upper portion of the brachial plexus become weak and fail to respond reflexly to stretching. Later they atrophy. Involvement of other parts of the plexus or other parts of the central nervous system results in the production of symptoms and signs appropriate to the site affected. There is no correlation between

the site at which the serum is injected and the site at which the nervous system reacts. For example, lesions of the brachial plexus have occurred as reactions to serum injected into the abdominal wall.

LESIONS OF THE PERIPHERAL NERVES

Of the many lesions of the peripheral nerves of the upper extremity, those of the median and ulnar nerves are most likely to result in significant pain. The ulnar nerve, as it passes through the groove between the olecranon process and the medial epicondyle at the elbow, is particularly vulnerable to pressure or other types of injury. If the groove is shallow as the result of an old fracture at the elbow, the nerve becomes placed more superficially and is more easily injured. Painful types of paresthesia often result from prolonged pressure on the ulnar nerve, such as that which occurs when the elbow is rested on the unpadded arm of a chair, the window rest of an automobile or the hard surface of a desk or table. The sensory phenomena occur in the little finger and, usually, in the ulnar half of the ring finger, the ulnar portion of the hand to the wrist and, less frequently, in the ulnar side of the forearm. Atrophy of the dorsal interosseal muscles and those of the antithenar eminence occurs when the condition is advanced and may be associated with weakness of the muscles supplied by the ulnar nerve with anesthesia in that part of the skin supplied by the ulnar nerve, and with a claw position of the fourth and fifth digits.

The median nerve has a more protected course than has the ulnar nerve. Injury of the median nerve results from fractures, lacerations and penetrating wounds. Physicians should remember that unskillfully performed venipuncture in the antecubital fossa may lead to injury of this nerve. Causalgia is a complication of injury to the median nerve that is to be feared. Atrophy of the thenar eminence, clawing of the second and third digits and the assumption by the thumb of a position in a plane with the fingers characterize the later stages of the more severe lesions of the median nerve. In addition to weakness localized to the muscles supplied by the median nerve, anesthesia may occur in the radial aspect of the palm, the palmar surface and the peripheral dorsal aspect of the first four digits.

Pain is not often prominent in lesions of the radial, musculocutaneous, axillary, long thoracic, dorsal scapular and suprascapular nerves. When it is present it is most often secondary to the mechanical factors resulting from paralysis of the muscles supplied by these nerves.

The glomus tumor, composed of nerve tissue and blood vessels, may give rise to agonizing pain which extends throughout the upper extremity. The pain can be reproduced by pressure over the tumor, and often by exposure to cold. The tumor often can be seen beneath the nail as a purple spot. Surgical exploration verifies the diagnosis and removal of the tumor meets with most gratifying results.

COMMENT

The problem of pain in the upper extremity is not a static one. Solid contributions to understanding and therapy are accumulating. There is need, however, for more study so that knowledge may supplant notions. In the present state of limited knowledge many instances of pain in the arms cannot be solved.

It is imperative that every case be considered in an unbiased manner. We must not rely too much on favorite tests. For example, depression of the shoulder aggravates the pain of the scalenus syndrome, but it may also aggravate the pain of protruded intervertebral disk in the cervical region or the costoclavicular syndrome, certain motions of the neck may intensify or alleviate the pain of protruded disk, but this does not always serve to distinguish protruded disk in the cervical region from cervical arthritis or even tumor of the spinal cord. The age, sex, occupation, temperament of the patient, and history and results of clinical and laboratory tests all must be considered and given appropriate weight in formulation of the final opinion.

The current tendency of physicians to think of protruded intervertebral disk in the cervical region when pain occurs in the upper extremities is commendable, but the diagnosis must be established beyond doubt if the wholesale errors of the era of the scalenus syndrome are to be avoided. Furthermore, the physician should keep in mind the fact that surgical exploration for protruded intervertebral disk in the cervical region, which often presses against the spinal cord, is fraught with greater hazards than similar exploration for protruded disk in the lumbar region, since the latter disk is situated relatively far from the spinal cord itself. Hence, the increased risk of surgical exploration in the cervical region should impel physicians to pursue the conservative treatment of protruded disks in the cervical region more tenaciously, and serve to keep alive the memory that, as in many cases of protruded disks in the lumbar region, recovery may take place without surgical intervention.

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ORTHOPEDIC ASPECTS OF PAIN IN THE SHOULDER AND ARM

H HERMAN YOUNG

WITHIN the relatively short span of this paper, it will be impossible to consider completely all of the orthopedic conditions that may cause pain in the shoulder and arm. Codman, in his book of more than 500 pages, considered only a few of the more common lesions of the shoulder and omitted a detailed consideration of such lesions as osteomyelitis, tuberculosis, tumors and fractures. The knowledge that such lesions do exist, however, is essential in making a diagnosis but, for the sake of brevity, only the more common lesions will be considered in this paper.

There are two types of pain in the shoulder and arm that are caused by orthopedic conditions: (1) referred pain which is produced by irritation of the sensory roots of the spinal nerves in the cervical segment of the spinal column and (2) pain caused by pathologic changes in the shoulder joint or its adjacent structures. Each of these types of pain may be caused by trauma or disease. The orthopedic conditions that may cause pain in the shoulder and arm are listed in table 1.

INJURY OR DISEASE OF THE CERVICAL SEGMENT OF THE VERTEBRAL COLUMN

In cases in which pain in the shoulder or arm is due to disease or injury of the cervical segment of the vertebral column, the pain is referred through nerves which arise from the irritated roots. The intervertebral foramina are essentially closed tubes formed by notches in adjacent vertebrae. Posterior to the notches are the articular facets with their capsules, and anterior to the notches are the vertebral bodies and the intervertebral disks. The sensory root ganglion is situated within the confines of the tube thus formed, and under ordinary circumstances there is ample room for the sensory root with its ganglion and for the motor root. Under abnormal conditions, the intervertebral foramina become narrow and their walls press on the nerve roots and cause local irritation which projects pain to the shoulder and arm. Narrowing of the intervertebral foramina first constricts the sensory root of the spinal nerve and causes pain.¹¹ Further narrowing constricts the motor root and causes paralysis. Trauma and disease which cause narrowing of the intervertebral foramina and consequent constriction of the last five cervical nerves and the first thoracic nerve may cause pain in the shoulder and arm. In cases in which the pain occurs

after an injury of the neck, a fracture or dislocation of the cervical vertebrae should be suspected. In the absence of a history of trauma, one should suspect the presence of a tumor, destructive arthritis or osteo-arthritis.

TABLE 1—ORTHOPEDIC LESIONS THAT MAY CAUSE PAIN
IN THE SHOULDER AND ARM

I Lesions of the cervical segment of the vertebral column

A Traumatic lesions

- 1 Fractures
- 2 Dislocations
- 3 Sprains
- 4 Arthritis

B Nontraumatic lesions

- 1 Arthritis
 - a Osteo-arthritis
 - b Rheumatoid arthritis
 - c Septic arthritis
- 2 Infection of the intervertebral disks
- 3 Osteomyelitis
- 4 Tuberculosis
- 5 Syphilis
- 6 Tumors

II Lesions of the shoulder and shoulder girdle

A Traumatic lesions

- 1 Fractures
- 2 Dislocations
- 3 Sprains
- 4 Rupture of tendons
- 5 Bursitis
- 6 Hemarthrosis

B Nontraumatic lesions

- 1 Acute lymphadenitis
- 2 Arthritis
 - a Osteo-arthritis
 - b Rheumatoid arthritis
 - c Septic arthritis
- 3 Osteomyelitis
- 4 Tuberculosis
- 5 Neurogenic arthropathy (Charcot's disease)
- 6 Tenosynovitis
- 7 Bursitis
- 8 Periarthritis
- 9 Fibrositis and myositis
- 10 Tumors
- 11 Myositis ossificans

INJURY OR DISEASE OF THE SHOULDER GIRDLE

Lesions of the shoulder joint and its adjacent structures are a far more frequent cause of pain in the shoulder and arm than are lesions of the cervical segment of the vertebral column.

Subacromial (Subdeltoid) Bursitis—Eight bursae around the shoulder joint are described in *Gray's Anatomy*. The largest and most important of these is the subacromial, or subdeltoid, bursa which is situated between the head of the humerus and the acromion process of the scapula. It is a synovial sac approximately $1\frac{1}{2}$ inches (3.8 cm.) in diameter. Its floor is attached to the joint capsule and its roof is attached to the acromion process. Ordinarily, the walls of this sac are separated by just sufficient fluid to allow one surface to glide smoothly over the other in order to prevent friction between the greater tuberosity and the acromion process. Under abnormal circumstances this bursa may become inflamed and distended with fluid; its walls may become adherent or it may contain calcium deposits within its lumen. If these conditions exist, the bursa causes acute or chronic pain in the shoulder and arm. In eighty-nine (53 per cent) of 163 cases of pain in the shoulder that were reviewed by Wilson, the pain was due to a lesion of the subacromial bursa. Haggart and Allen made a study of 300 consecutive cases of painful shoulder in which the patients were adults. In 79.5 per cent of these cases there were lesions in or related to the subacromial bursa and tendons of the short rotator muscles. Lesions of the bursa, therefore, are the most frequent local cause of pain in the shoulder.

To Codman (1904) belongs the credit for emphasizing the importance of the shoulder bursae although he acknowledged in his book that Kuster had described subacromial bursitis two years previously.

Chronic subacromial bursitis with calcification is probably the most frequent local cause of pain in the shoulder. This pathologic condition is no respecter of vocation, and it affects men as well as women. In the twenty-five cases of calcification of the subacromial bursa reported by Wilson, the patients were between thirty-one and sixty-five years of age and the greatest incidence occurred between the ages of forty-six and fifty years. This was in contrast with Wilson's series of thirty-six cases of periarticular adhesions in which the peak of incidence was between the ages of fifty-six and sixty years. The exact pathologic nature of calcification of the subacromial bursa is not known. Most observers agree with Codman, who said that the original calcium deposit occurs in the short rotator tendons of the musculotendinous cuff and that the most frequent site of such deposit is the tendon of the supraspinatus muscle. Acute or chronic trauma or overuse leads to a rupture of a few fibers of the tendon and to the formation of a hematoma, which later becomes the site of deposits of calcium phosphate or calcium carbonate. This calcification, however, does not always cause symptoms as many authors have reported the occurrence of symptomless calcified bursae or tendons. Just what makes these deposits suddenly become painful is likewise unknown. Usually there is a history of slight trauma immediately preceding the sudden onset

of symptoms The calcium deposits could not have occurred in the intervening few days, therefore, they must have been present prior to the trauma The injury, however, produces irritation and inflammation of the bursa, which is well supplied with blood vessels and nerves, and symptoms become manifest The patient complains of pain at the tip of the shoulder, in the region of the attachment of the deltoid muscle to the humerus or even in the forearm and hand That such extension of pain can be caused by lesions of the bursa was demonstrated by Moseley When 5 per cent saline solution was injected into the supraspinatus tendon, pain was referred to the insertion of the deltoid muscle and even to the forearm and hand Likewise, pressure on a calcified deposit that is being operated on under local anesthesia will produce similar pain The patient with calcified bursitis feels the pain mainly on attempts to abduct or rotate the humerus These motions, which are usually limited both actively and passively, irritate the walls of the bursa and produce pain Pressure over the tip of the shoulder elicits tenderness Finally, the diagnosis is made by the roentgenologic examination and the finding of a calcium deposit in the region of the supraspinatus tendon or subacromial bursa

Occasionally an acutely inflamed subacromial bursa will be observed The patient with such a lesion complains of agonizing shoulder pain which prevents motion of the shoulder and interferes with his sleep The pain usually is sudden in onset and may be referred to the insertion of the deltoid muscle or to the forearm The patient holds his arm at his side and walks the floor because of discomfort Morphine alone may produce relief Examination will disclose that, although anterior and posterior motions in the shoulder joint are free and painless, abduction and rotation of the humerus are extremely painful and these motions are greatly restricted There is marked tenderness over the tip of the shoulder, and some swelling may be observed The roentgenologic findings may be entirely negative or may reveal the presence of a calcium deposit in the region of the subacromial bursa

That the treatment for this condition is not specific is attested by the numerous types of treatment that have been advocated A complete consideration of all methods used does not fall within the scope of this paper, which is mainly concerned with diagnosis For the acute lesions, injection of procaine hydrochloride, application of heat and surgical drainage have been used with beneficial results In the case of more chronic lesions, diathermy, physical therapy, injection of procaine hydrochloride, roentgen therapy, and surgical excision all have their advocates For a more detailed consideration on the treatment, the reader is referred to the several excellent articles included in the references 2-5 10-13 15

Periarthritis.—In close competition for the local lesion that most

Masquerading under the

articular adhesions," "adhesive bursitis"

condition seems to be little understood by the medical profession at large. It has been my frequent impression that the disability has often been prolonged, yes, even produced, through ill-advised management. Usually, when the patient consults a specialist the condition is fully developed. The patient complains of pain in the shoulder and of stiffness and loss of motion. The pain may vary from a "catch" to a dull ache which is aggravated into sharp pain by motion. Night pain frequently is present and the patient has noticed an inability to get his hand behind his back or up over his head, or even to his face. What produces the lesion is unknown. Presumably, there are adhesions between the walls of the bursae of the shoulder joint, along the tendons of the shoulder or in the capsule and musculotendinous cuff. Injury, overuse or even mild infection may precede the onset of the condition, which is encouraged by the assumption of the sling position and by disuse of the joint. Eventually, the shoulder becomes "frozen." There is no swelling or point tenderness, but abduction and rotation of the humerus are markedly limited. With the scapula fixed, abduction of 35 to 45 degrees frequently is all the motion that is present, and forced motion beyond this point is painful. Anterior and posterior motion of the arm is not restricted. Roentgenologic examination usually does not disclose any abnormality but, as time passes, osteoporosis develops as a result of disuse.

The treatment of the frozen shoulder is all important. Too often the advice is given to rest the arm and carry it in a sling. This is contrary to my observation that the pain persists as long as motion is restricted and that it disappears only as motion is regained. In some cases, the use of haking, massage and gradual stretching exercises eventually may produce a relief of the symptoms and a restoration of motion of the shoulder. Other patients will require manipulation of the shoulder under anesthesia followed by the same physical therapeutic measures over a prolonged period of time. When manipulation is performed, snapping sounds and sensations are present and presumably are due to the breaking of adhesions which ordinary physical therapeutic measures were unable to break or stretch. Caution must be used in the manipulation, however, lest the shoulder be dislocated or the humerus fractured.

Rupture of the Supraspinatus Tendon.—To Codman also belongs the credit for calling attention to rupture of the supraspinatus tendon as a cause of pain in the shoulder. For the diagnosis of this condition, he enumerated eighteen points.

The following hypothetical case may serve to illustrate the historical and clinical findings. The patient is a laborer, aged forty years

or more, who has sustained an injury to a previously asymptomatic shoulder and suffers immediate pain of short duration. The following day, the shoulder becomes painful again and the pain is accompanied by an inability to abduct the arm actively. Examination discloses faulty scapulohumeral rhythm, tenderness over the tip of the shoulder, a sulcus at the point of the tear and soft crepitus over the greater tuberosity. Pain is produced as the tuberosity disappears under the acromion and reappears as it emerges. Roentgenographic examination does not disclose any abnormality.

The most important factor in making the diagnosis of a torn supraspinatus muscle lies, however, in the recognition of the loss of function of this muscle. It is impossible for the deltoid muscle alone to abduct the arm since its resolved line of pull lies inside the fulcrum, thus making it an adductor. The line of pull of the supraspinatus muscle lies outside the fulcrum, and its contraction initiates abduction, bringing the arm to the position in which the deltoid becomes an abductor and can complete the movement. Again, as the abducted arm descends to the side, the function of the supraspinatus muscle provides for a smooth motion. If the arm first descends smoothly and then suddenly falls to the side, the intactness of the supraspinatus muscle should be questioned.

Space does not permit a consideration of the treatment of this condition. Some surgeons believe in operative interference and suturing of the tendon while others feel that conservative treatment, including immobilization of the arm in abduction, will produce a satisfactory result.

Muscle Sprains and Fibrositis.—No consideration of pain in the shoulder would be complete without mentioning local muscular disturbances that can produce pain. Undue or unaccustomed use of the shoulder may produce a sprain which causes pain and stiffness. The sprain may be in any of the muscles of the shoulder girdle and lead to a temporary disability of the shoulder and arm that responds well to conservative treatment.

Travell, Rinzler and Herman described a painful condition of the muscles of the shoulder girdle which they chose to call "idiopathic myalgia" and which I wonder if other physicians have not called 'fibrositis'. In this condition localized areas of tenderness are found within the muscles. These areas refer pain into the shoulder and arm along pathways experimentally studied by Lewis and Kellgren.^{6, 7, 8} When these areas are present in any muscle innervated by the fifth cervical to the first thoracic nerves, they may refer pain to the shoulder or arm, and it is interesting that the condition is relieved by injections of procaine hydrochloride.

SUMMARY AND CONCLUSION

It is obvious that in the short span of a single paper not all orthopedic lesions that can produce pain in the shoulder and arm can be considered. Accurate diagnosis depends on a complete history, on careful physical examination and on indicated laboratory tests and roentgenographic examination.

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CLINICS ON OTHER SUBJECTS

CRANIOPLASTY WITH TANTALUM PLATE IN THE POSTWAR PERIOD

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THE effectiveness of tantalum plate in the rehabilitation of thousands of persons who had suffered from battle casualties with large cranial defects was clearly demonstrated in the recent world war. During the postwar years the adaptability of this metal to the needs of the surgeon in many reconstructive procedures has already been realized. The fact that tantalum plate is malleable and can be molded into the proper shape at the operating table makes it unquestionably very useful for many neurosurgical procedures at the time of the original operation. In such conditions as osteomas of the skull, depressed skull fractures, brain tumors involving bone, primary granulomas of the skull, dermoids, occipital meningoceles, frontal burr holes and many other conditions in which defects of the skull may result from the primary surgical procedures, cranioplasty with tantalum can be easily accomplished at the same operation. When the repair of a cranial defect is necessarily secondary, it is perhaps best to mold the plate prior to operation by one of the methods to be described later in this paper. In inflammatory reactions such as osteomyelitis of the skull, brain abscess, compound comminuted skull fractures, devitalized bone flaps and so forth, the cranioplasty should be done as a secondary procedure when the spread of infection has been definitely controlled.

In spite of the fact that tantalum is a relatively inert metal and primary healing of the contaminated wound is accomplished, the patient should receive large doses of penicillin prior to cranioplasty and administration of the drug should be continued for several days of the postoperative period to obtain the best results. Whether the defect is covered at the time of the original operation or at a later date will depend on the type of case at hand and the judgment of the surgeon. Chemotherapy may alter one's opinion with regard to this.

METHODS OF MAKING THE PLATE

A tantalum plate can be easily made at the operating table¹ when the defect is not complicated. The defects difficult to repair are those that occur in the frontal bone with involvement of the frontal sinuses. In these cases the cosmetic result is of paramount importance. Few



Fig 330—Die and counter die method of forming the plate

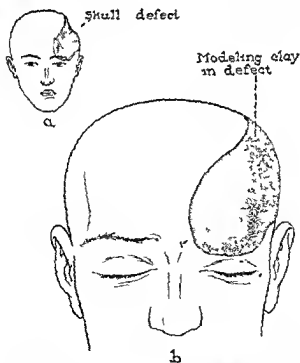


Fig 331—Direct method of forming the plate In *a* the skull defect is shown In *b* the defect has been filled with modeling clay

special instruments are necessary for making the plate at the table and these can be sterilized with others that are necessary to complete the operation. The size of the defect is measured by a piece of sterile lead foil or cottonoid. The tantalum plate is then cut with scissors from the pattern. It is easily shaped by hammering over a concave metal mold until it assumes the contour of the removed bone.

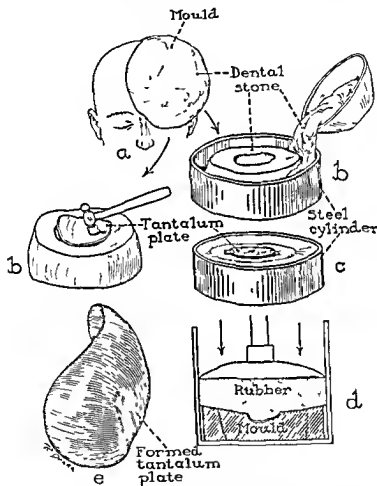
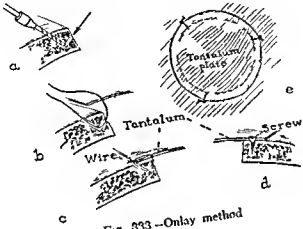


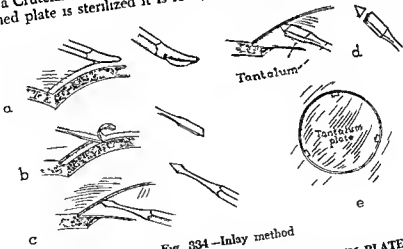
Fig. 332.—*a*, Making the mold direct from patient. *b'*, Hammering the plate into shape on the mold. *b* and *c*, Securing the mold in the steel cylinder preparatory to swaging the plate in a power press. *d*, Swaging the plate. *e*, The formed plate.

When the operation is a secondary one, it is perhaps best to mold the plate prior to operation by the die and counter die method² as demonstrated in figure 330 or by the direct method¹ as shown in figures 331 and 332. The scalp is cleanly shaved and in each case an identical mold of the defect is obtained, allowing $\frac{1}{4}$ to $\frac{1}{2}$ inch (0.6 to 1.3 cm.) extension beyond the edge of the bone. The plate is cut to

proper size. Either it is hammered into shape on the mold (fig 332, b') or a power press is used to swage the metal as in figure 332, d. The latter method is recommended when a press is available. The thickness



if the temporal muscle must always be accommodated for making plates in the temporal region. Small holes can be made in the plate with a Crutchfield brace and dental burr, or a metal punch. When the finished plate is sterilized it is ready for insertion.



TECHNIC OF CRANIOPLASTY WITH TANTALUM PLATE

The scalp is cleanly shaved and prepared for operation as in craniotomy. Local anesthesia is recommended in most cases, but complicated repairs are best handled while the patient is under general

anesthesia or a combination of the two Attempts should be made to resect scars of the scalp when secondary procedures are being done The primary repairs are completed through the original exposure, but in secondary operations it may be necessary to make a new incision for adequate blood supply to the flap and for better exposure of the defect Once the area has been satisfactorily exposed two methods of insertion of the plate are in use to complete the cranioplasty, namely, the onlay method as demonstrated in figure 333, and the inlay method described by Hemberger, Whitcomb and Woodhall³ as shown in figure 334 The secondary repairs often require injection of solution of penicillin (10,000 units per cubic centimeter) under the plate or scalp flap as prophylaxis against reinfection Fibrin foam that has been saturated with penicillin and thrombin has been used to good advantage by the author in such cases when control of hemostasis was difficult in old scar tissue and a concentration of penicillin was desirable for bacteriostasis to safeguard against infection

Compression dressings of sponge latex or mechanic's waste are advisable to prevent accumulation of fluid beneath the flap When fluid appears it should be removed by aspiration and a compression dressing should be reapplied The tissues of the scalp soon become adherent to the tantalum plate and it is a very rare occasion when the plate has to be removed because of foreign body reaction

CONCLUSIONS

The cosmetic appearance of patients who have submitted to cranioplasty has been unusually gratifying The physiologic effect of covering the defect of the skull in posttraumatic cases has invariably improved the symptoms of vertigo and headache The psychologic advantage to the patient has been a notable accomplishment

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PROBLEMS OF FACIAL PROSTHESIS

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PROSTHESES OF THE BODY IN GENERAL

THE use of prosthetic devices to replace the missing parts of the leg and the arm today is an accepted standard orthopedic procedure for restoration of partial function. Prosthesis of the eye is another common and well established method of somatic reconstruction which is used purely for cosmetic effects. The most outstanding example of prosthesis which combines function and aesthetics with a high degree of success is dental restoration of all types, such as full and partial dentures, crowns and bridges. However, the use of prosthesis for replacement of the soft parts about the face, such as the nose, the ears, parts of the cheek and so forth, never has been widespread. Consequently, its theory and technic have not been well developed. Surgeons and the public have not been made fully aware of the possibilities of reconstruction of facial deformities by prosthesis. The psychologic effect of any type of facial disfigurement is of course obvious, and the need for a method of reconstruction other than the grafting of tissue, in cases in which plastic surgery is unable to cope with the situation, needs no emphasis.

INDICATIONS FOR PROSTHESIS AND FOR PLASTIC SURGERY

Generally speaking, prosthesis of the soft parts of the face is admittedly a procedure of second choice, chiefly because (1) no substitute that man can possibly devise can be as good as surgical reconstruction from autogenous tissues, (2) successful wearing of a facial prosthesis requires constant personal attention and often is a source of annoyance and inconvenience, and (3) such a prosthesis requires frequent replacement if it is desired that realistic appearance be maintained.

These are valid reasons why facial prosthesis should be considered to be merely a temporary expedient, at most, if there is any possibility of obtaining satisfactory results by grafting. However, plastic surgeons frequently are confronted with certain types of facial disfigurement for which surgery is not considered advisable. This is usually the case when the patient is too old or is in poor health, or when the tissues at the site of the deformity are unhealthy, or when the deformity involves extensive loss of tissue or consists of loss of the auricle, in which latter case the length of time involved in surgical reconstruction and the results that might be expected therefrom do not warrant its

use Under such circumstances prosthesis, in spite of its disadvantages, becomes a method of first choice, and should be employed as such

STATUS OF FACIAL PROSTHESIS TODAY

It might be asked at this point why it is that methods and techniques of facial prosthesis, as compared with other types of prosthesis which have been referred to previously, appear to have been neglected, in spite of the fact that the need for facial prosthesis is no less urgent As a partial answer to this inquiry, three important reasons can be offered (1) limited application, (2) availability of a, generally, more desirable alternate method (plastic surgery), and (3) technical difficulties

Limited Application.—Instances of facial deformities, traumatic pathologic or congenital, for which prosthesis is indicated are not so numerous compared with other somatic deformities which require prosthesis Certainly, they are not so numerous as cases in which dental prosthesis is required Hence, it is only natural that interest in the technic of facial prosthesis should have been correspondingly limited

Availability of a Generally More Desirable Alternate Method (Plastic Surgery).—Let it be assumed, for the moment, that skin grafting had been found to be as impracticable or impossible as the grafting of a leg or an eye or teeth It would be logical to assume, under such circumstances, that more attention would have been given to the technic of facial prosthesis Generally, in any form of human endeavor in which more than one method for the solution of an urgent problem is available, that method which seems to offer success in most cases will receive the greater attention Conversely, when only one method of approach to a problem is at hand, that method will receive undivided attention In the particular case under consideration it is reasonable to assume that the availability of a better method of reconstruction, in the form of grafting, has had a retarding effect on fuller investigation of the alternate method in question

Technical Difficulties.—Aside from the two aforementioned theoretic conjectures, however, there are real difficulties in the matter of improvement in technic These difficulties are peculiar to facial prosthesis They can be set forth best by comparison of the technical problems involved in other types of prosthesis with those of facial prosthesis

Prosthesis of the Leg—Prosthesis of the leg may be considered first In this case the device is primarily a functional aid As a rule, no part of the prosthesis is seen while it is in use Consequently, the problem of appearance, which in facial prosthesis involves such complex factors as form, color, translucence texture and concealment of the line of juncture between the prosthesis and the body, virtually does not exist

Next, in most cases, the presence of a stump serves adequately as a means of attaching the prosthetic device to the body. If, in any type of prosthesis, the problem of *appearance* and *retention* just referred to does not exist or, if it is present, is readily surmountable, then satisfactory solution of the third remaining problem, *durability*, becomes automatically simplified.¹⁰

Prosthesis of the Eye—In prosthesis of the eye the task is somewhat different, although certain very favorable anatomic conditions peculiar to the site of that organ, are similarly of great value in the solution of the problem of prosthesis of this organ. An almost ideal condition exists for retention of the prosthetic globe by the presence of (1) a deep cavity, and (2) the two enveloping muscular membranes. The latter not only aid retention of the prosthesis, but also serve admirably to hide the line of juncture between the prosthesis and the body. This juncture otherwise would be very noticeable and difficult to conceal. The problem of aesthetics in a prosthetic eye is of paramount importance. Fortunately, the attainment of aesthetics under these favorable circumstances is comparatively easy. Additional factors which further contribute to the success of prosthesis of the eye should be mentioned. First, since the globe is relatively rigid, it can be reproduced best prosthetically in a rigid material, and rigid materials, such as glass or even the newer plastics, are, as a rule, much more durable and consequently hold their shape and color far better, than do soft and pliable substitutes. Second the permanency of the delicate and lifelike coloring of a prosthetic eye is further safeguarded by a protective coat of body fluid which protects it from the fading effect of dust, smoke and sunlight and, in addition, gives it a shiny and lifelike appearance.

Dental Prosthesis—A consideration of dental prosthesis also will reveal anatomic factors very favorable to success of the procedure. When full dentures are employed the alveolar ridges and the buccal muscles, in combination with atmospheric pressure, in most cases provide the physical means for retention of the prosthesis. Where partial dentures are used the remaining teeth provide firm and convenient points of anchorage. The lips, in addition to aiding in retention, constitute an excellent curtain for hiding the line of juncture. The hard character of the teeth makes it only logical that the substitutes have a similar quality. That part of the prosthesis which represents the gingivae also can be made rigid which means that, as is true in the case of prosthesis of the eye, comparative permanence of form and color is assured. Finally, the presence of saliva, in addition to its protective action over the teeth and gingivae, helps to make the artificial substitute more natural in appearance than would be possible otherwise.

PROBLEMS PECULIAR TO FACIAL PROSTHESIS

It is now possible to return to the main problem, which is that of supplying a patient with a prosthesis which involves the face. An example would be a prosthetic nose. Several anatomic difficulties are interposed at the site of a proposed prosthetic nose. First, there is nothing that is comparable to the very favorable anatomic conditions which have been shown to exist at the site of a prosthetic eye or that of dentures. Therefore, the task of keeping the prosthetic nose in place securely, and of hiding or camouflaging the unavoidable line of juncture between the prosthesis and the skin, immediately confronts and greatly handicaps the prosthetist.¹²

Second, the tissue which the prosthesis is intended to simulate is soft, translucent and delicately pigmented, possessing a surface texture which is peculiar to skin. Faithful reproduction of all these physical characteristics, although difficult to attain, is even more difficult to maintain unchanged while the prosthesis is in use.

Third, the prosthesis, no matter what material is used, cannot be made as soft and as pliable as skin, so that it will move along with the muscles of the face with which it is in contact.

Fourth, the situation of the prosthesis is such that the material of which it is made and the color of the material cannot be benefited by the protective action of body fluids against the harmful effects of the atmosphere, such as wind, dust, chemical fumes and the like.

Fifth, constant changes in the color of the natural skin caused by changes in circulation and seasonal changes caused by ultraviolet rays further complicate the problem of attainment of realistic appearance.

SUCCESS IN FACIAL PROSTHESIS

Materials Available.—Although success in any prosthetic reconstruction of soft tissues about the face depends to a large extent on such factors as (1) the site and extent of deformity, (2) the nature and contours of the tissue surrounding the deformity, and (3) the patient's willingness to co operate and his determination to wear the prosthesis, ultimate success must lie in the ability of the prosthetist to solve the problems which have been listed as being peculiar to facial prosthesis. Theoretically, the solution of most of these problems can be accomplished by an "ideal" material with which to work, but such a material thus far has not been found.¹¹ It is true that certain materials have been used with some degree of success. Examples are pre-vulcanized liquid latex and plasticized plastics. These possess good translucence, satisfactory molding quality, fair compatibility, some degree of physical stability and washability, all of which are prerequisites for a material to be used in facial prosthesis. Yet these materials are (1) not light enough in weight to simplify the problem of reten-

tion, (2) not sufficiently durable to maintain the feather-edges which help to blend with the skin at the juncture, nor to withstand rapid deterioration after moderate use, (3) not sufficiently stable to the action of sunlight, smoke and other conditions present in the atmosphere, and (4) not quite soft enough to respond to the action of facial musculature.

The evolution of facial prosthesis, so far as the all important question of a perfect material is concerned, has been intimately associated with two main types (1) rigid materials and (2) flexible materials. The former type has offered strength and durability and some degree of permanence with much sacrifice of lifelike quality. The latter type has offered lifelike appearance at the expense of durability. The selection of one type to the exclusion of the other always introduces a set of compromises which usually involves sacrifice of appearance for the sake of durability, or vice versa. In a given case the individual requirements of the patient and the type of deformity to be repaired often determine which type of material should be used.

Rigid materials,^{2 3 27} such as vulcanite, were used for reconstruction of noses and ears before the introduction of the first pliable material in the form of gelatin glycerin mixture.²⁸ This mixture had a lifelike appearance but, unfortunately, the wearing quality of the material was very poor. A prosthesis made from it could not last more than a week or so. Consequently, the gelatin glycerin mixture never was used widely. Most experienced prosthetists felt that they could serve the patient best with vulcanite or a similar rigid material.^{1 14 18 19} The newer plastics (the so called acrylics and the like), with their improved translucence and color possibilities, have replaced vulcanite as a rigid prosthetic material in the hands of some workers.^{20 22} In the meantime, search for a better pliable material has not been neglected by workers in the field in question. Those interested in the problem felt that if a material possessing the lifelike qualities of the gelatin glycerin mixture with some degree of durability could be found, a distinct improvement could be expected. Rubber restorations made from liquid prevulcanized latex, in spite of the shortcomings of this material, have gained considerable favor among facial prosthetists in the past eight years.^{4 6 8 9 15 17 21} In the opinion of some, it is the material of choice. A material more recently introduced, and one now being tried out by various workers, consists of a variety of plastics made pliable or rubber like by the addition of proper plasticizing agents.^{13 23-26}

There are certain advantages in these resilient plastics that cannot be overlooked. They may, in time, replace latex for some kinds of facial prosthetics. The wide range of flexibility in which these plasticized plastics can be made available is a decided advantage. From the aesthetic standpoint, the results that are obtainable from it are

TABLE 1.—EVALUATION* OF PRINCIPAL MATERIALS THAT HAVE BEEN AND ARE BEING USED FOR FACIAL PROSTHESIS,
FROM THE STANDPOINT OF SUITABILITY AS A PROSTHETIC MATERIAL

Materials	Compatibility with Tissue	Pliability	Skinklike Softness	Leakiness	Translucence	Colours & Possibilities	Ease of Molding or Casting	Ease of Hollow Casting	Ease of Molding Featheredges	Ease of Duplication	Possibility of Molding in Plastic or Felt Mold	Lack of Shrinkage during Molding	Poor Thermal Conductivity	Color Retention	Nonbreakage	Stability of General Form	Stability of Featheredges	Resistance to Action of Liquid Adhesives	Adhesion to Skin with Liquid Adhesives	Cleanability	Sum of Ratings
Wood	4	0	0	3	0	1	2	0	1	1	0	4	4	3	4	4	4	4	4	2	41
Wax compounds	3	0	0	3	4	4	4	2	2	4	5	4	5	3	0	0	0	0	1	2	41
Ivory	4	0	0	2	3	2	0	0	12	1	0	5	4	2	4	5	12	5	4	3	48
Metals gold, silver, copper	4	0	0	1	0	1	3	1	3	2	0	5	0	2	5	5	3	5	4	3	50
Vulcanite (hard rubber)	4	0	0	2	0	2	3	0	2	2	4	5	4	3	3	4	12	1	4	1	52
Celluloid (shells)	4	2	0	3	1	2	3	1	3	3	3	5	4	4	4	1	1	3	4	0	60
Gelatin-glycerine mixture	4	4	0	3	5	3	5	1	3	5	5	5	4	3	5	1	0	3	1	1	61
Rigid plastics (acrylics etc.)	4	0	0	3	5	3	3	4	3	3	4	5	4	1	3	1	2	1	1	4	66
Prevulcanized latex compound	4	4	0	4	3	4	5	5	3	5	5	1	4	3	5	1	2	1	1	4	69
Plasticized plastics	3	1	0	3	5	5	4	2	3	4	1	5	4	3	5	1	3	3	2	1	70
Ideal material	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	100

* Explanation of rating 0, none, 1 very poor, 2, poor, 3, fair, 4 good, 5 excellent

slightly superior to those that are obtained from latex. With pliable plastics it is possible to produce dimensionally accurate restorations. The plastics have greater color possibilities. When latex is used, the problem of shrinkage is always present.¹⁶ On the other hand, the technique of molding latex restorations is simple as compared with that of molding plastics. Latex lends itself admirably to the casting of hollow structures and hence is well suited for use in light weight restorations. The liquid adhesives often used for the retention of prosthetic devices are more effective in combination with latex than they are in combination with the known types of plasticized plastics. It must be admitted, however, that although the results obtainable from these two types of pliable materials now commonly in use—latex and plasticized plastics—represent a distinct advancement over earlier attempts at facial prosthesis, even these newer materials are not perfect in all respects. The search for an 'ideal' material is not ended.

In table 1 which is a modification of an earlier table published by myself,⁷ is presented an evaluation of ten materials, some of which have been used and others of which still are being used for prosthesis of the face. Each material is rated according to twenty qualities that are essential from a prosthetic standpoint. The comparative usefulness of each material in prosthesis has been indicated in the final column of this table, where the total score of the rating of that material in each of twenty traits has been computed. The rating is explained in the footnote to the table. The so called "ideal" material has a rating of 5 (excellent) in all twenty requirements and has a total rating of 100, which is interpreted as being 100 per cent satisfactory. Personal opinion regarding the evaluation of each type of material in this table no doubt will vary among different workers according to their experience with the material.

Indications.—Although it is true that the need for such prosthetic devices becomes more obvious and urgent as a result of war casualties, the need for prosthesis of the face for civilians in peacetime is equally urgent. The reason for this is that, if mutilation has not been too extensive, plastic surgery for a patient whose face has been wounded in battle usually can be undertaken at once. This is not always true in the case of the civilian who presents himself for correction of a facial deformity, because he may be confronted with two main contraindications to plastic surgical procedure, namely, (1) possible recurrence of the malignant process which may have caused the deformity, and (2) his advanced age or poor health. These two contraindications usually do not obtain in the case of a person whose face has been injured in battle.

In my experience, by far the largest number of patients referred to me for facial prosthesis have had deformities which have resulted from surgical removal of a malignant lesion, or from trauma sustained in a

civilian activity, or from congenital malformation. A large number of these patients later underwent plastic surgery done to make repair of the deformity more nearly permanent. For this group a prosthesis was considered the most desirable means of meeting the cosmetic requirements during the observation period intervening between surgical removal of the malignant process and institution of the plastic surgical procedure. In still other cases, the age or the physical condition of the patient made it desirable that a prosthesis be worn for an indefinite period. Six illustrative cases will be presented to suggest the possibilities of the application of facial prosthesis.

REPORT OF CASES

CASE 1—A man forty six years old first came to the Mayo Clinic on January 15, 1945, to be examined by the Section on Laryngology, Oral and Plastic Surgery because of a lesion on the tip of the nose which he had first noted four years prior to his visit. The lesion was diagnosed as grade 1 squamous cell epithelioma. Surgical diathermy was performed by Dr G B New on January 19, 1945. Removal of the lesion entailed loss of the tip of the patient's nose. On July 19, 1945,

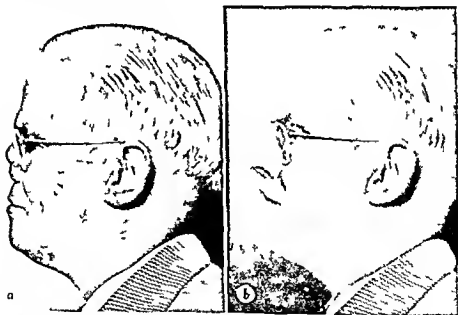


Fig 335 —a, Postoperative loss of portions of the soft parts of the nose, b, reconstruction of the nose with elastic plastic compound

the patient returned to the clinic because of what appeared to be recurrence of the neoplasm involving the septum and alae. Biopsy was performed and additional tissue was removed by surgical diathermy on July 25, 1945. The patient returned on October 16, 1945, for observation. No evidence of recurrence was noted at that time (fig 335 a). The patient was advised to wait for about eight more months before undergoing plastic surgery. A prosthetic nose was made for this patient to use during an additional period of observation (fig 335, b).

CASE 2—A man sixty-seven years old registered at the clinic on April 24, 1945, to be examined by the Section on Laryngology, Oral and Plastic Surgery. On several occasions he had been treated elsewhere with electrocoagulation and roentgen rays for a "sore" on the nose which he had noticed six years prior to his admission to the Clinic. Examination by Dr. New on April 26, 1945, revealed

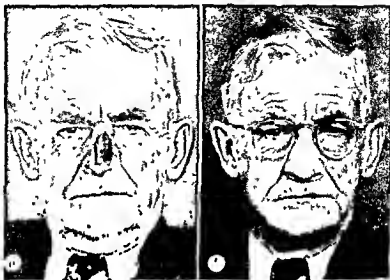


Fig. 336—*a*, Postoperative loss of the left side and dorsum of the nose, *b*, reconstruction of the nose with an elastic plastic compound

a postradiation recurrent epithelioma of the nose which involved the left side and extended across the nose just below the nasal bones. This lesion was removed by Dr. New on April 30, 1945. On August 10, 1945, a sequestrum was removed (fig. 336, *a*). The patient was referred for nasal prosthesis on September 22, 1945 (fig. 336, *b*).

CASE 3—A woman twenty-three years old was first examined at the clinic by the Section on Laryngology, Oral and Plastic Surgery on September 4, 1945. About four weeks prior to her admission she had been involved in a serious automobile accident, in which she had been pushed through the windshield. The accident had resulted in complete loss of the nose, in multiple scars about the face, and in deformity of both the upper and lower left eyelids (fig. 337, *a*). The extent of the injury and the physical condition of the patient at the time of examination, in the opinion of the examining surgeon, Dr. E. L. Foss, were such that immediate performance of a plastic procedure was not indicated. The patient was advised to delay the operation for six months. In the meantime she was supplied with a temporary prosthetic apparatus (fig. 337, *b*).

CASE 4—A man forty-two years old was examined by the Section on Laryngology, Oral and Plastic Surgery on November 6, 1944. He had a history of incomplete healing of a nasal ulcer which occurred five and a half years prior to his admission to the clinic.

He was referred to the clinic for examination by Dr. New on November 6, 1944. He had a history of a chronic ulcer of the right side of the nose which he had noticed when he had

fallen between the wheel of a tractor and a power belt. The abrasive action of the belt had caused much loss of tissue. On examination there were found in ad-



Fig 337—*a*, Deformity caused by an automobile accident, *b*, same patient wearing an interim prosthetic nasal device



Fig 338—*a*, Total loss of right auncle and small portion of the skin as the result of a farm accident, *b*, reconstruction of the lost auncle by prosthesis with latex compound

dition to loss of the auncle, an area of incomplete healing 1 by 2 cm and suspected sequestrum at the site of injury, which was confirmed roentgenologically (fig 338, *a*) Dr Foss removed the sequestrum on November 9, 1944, and the

patient was referred for prosthetic reconstruction of the ear as soon as the wound had healed sufficiently to permit the taking of an impression. The patient returned for prosthesis which was completed on March 8 1945 (fig 338 b)



Fig 330—*a* Total loss of the left auricle as the result of a truck accident *b* prosthetic reconstruction of the ear with latex compound



Fig 340—*a* Total loss of the nose and portions of tissue adjacent to it caused by lupus and diathermy *b* reconstruction by prosthesis

CASE 5—A man thirty two years old came to the clinic on February 11 1948 for consultation with the Section on Laryngology Oral and Plastic Surgery con

cerning reconstruction of the left auricle This structure had been totally lost two years previously in a truck accident The patient was referred by Dr J B Ench for a prosthetic reconstruction There was no apparent damage to the hearing or to the left external auditory canal, except for considerable diminution of the diameter of the external meatus as the result of formation of scar tissue (fig 339, a) The normal size of the canal just beyond this newly formed constriction created a favorable condition for retention of the proposed prosthesis A perforated "mushroom" type of plug was incorporated on the side of the prosthesis which came in contact with the skin This plug was gently forced into the canal, providing a firm anchorage and also a passageway for sound waves The thin edge of the prosthesis, anteriorly, was made to adhere to the skin with a "mastisol" type of liquid adhesive The prosthesis, which was made of latex, was completed on February 15, 1946 (fig 339, b)

Comment on Case 5—For patients whose auditory apparatus on both sides is unimpaired except for a missing auricle on one side, reconstruction of this part of the auditory organ appears to be a definite aid in re establishment of bi-aural hearing, for such patients seem to regain the power of localizing the origin of sound much better with the aid of the prosthesis

CASE 6—A man twenty six years old first came to the clinic on March 2, 1942, to be examined by the Section on Dermatology and Syphilology He complained of a cutaneous lesion involving the nose and the upper lip He had first noticed this lesion fourteen years prior to the time of his visit On examination the alae nasi and the cartilaginous portion of the septum were found to have been destroyed The tissue that had been the site of lupus was removed by Dr New with surgical diathermy Six months later skin was grafted to correct scarring and the resulting ectropion of the upper lip (fig 340, a) The patient was supplied with a prosthetic nose on October 21, 1942 (fig 340 b)

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MALIGNANT TUMORS OF THE SCALP

FREDERICK A. FIGI

MALIGNANT tumors of the scalp are encountered rather infrequently. They may occur either as primary or as secondary neoplasms. Most of the primary growths are epitheliomas and originate on the cutaneous surface; however, they may develop within sebaceous cysts or have their origin in mesodermal structures such as the pericranium, the lymphoid tissue or the blood vessels. Because of the anatomic structure of the scalp and its relation to the cranium and its contents, these neoplasms present special therapeutic problems. In cases in which lesions are extensive, plastic repair may involve as much difficulty as eradication of the tumor. A discussion of the different types of neoplasms occurring on the scalp and methods of treating them is presented.



Fig 341.—Squamous cell epithelioma, grade 1, of the scalp of a man, forty-four years of age, developing in a dense scar resulting from a burn in childhood.

PRIMARY MALIGNANT TUMORS OF THE SCALP

Epitheliomas make up the great majority of primary malignant tumors of the scalp. These may be either basal cell or squamous cell in type. Most of them have their origin on the surface of the skin but squamous cell epitheliomas at times arise within sebaceous cysts.

Squamous cell epitheliomas also often develop on the scalp in areas of actinodermatitis and in traumatic scars, especially in the thin, tense cicatrices resulting from burns and from avulsion of the scalp (fig 341) Repeated localized trauma to an inflammatory lesion in this

Fig 342



Fig 343



Fig 344

Fig 342—Extensive basal cell and squamous cell epithelioma grade 1 of scalp

Fig 343.—

Fig 344—Result in case shown in figures 342 and 343 showing extensive scar and application of full thickness skin graft

situation has appeared at times to be a definite etiologic factor in the development of such lesions. In general the epitheliomas of the scalp are slow to invade the deeper structures and they metastasize late. Even though the primary lesion covers a considerable portion of the scalp and is fixed to the cranium, the regional lymph nodes often re-

main free from involvement. The nodes may, in fact, be palpably enlarged in the mastoid, preauricular, occipital and posterior cervical regions because of inflammatory reaction in the tumor of the scalp and yet no malignant extension into these structures be present. When metastasis occurs it is most likely to be in the mastoid, the posterior cervical and the occipital nodes. Most of the malignant lesions originating on the surface of the scalp show a tendency to spread laterally or to produce a papillary or fungating mass rather than to invade deeply (figs. 342, 343 and 344). The tough, fibrous galea aponeurotica probably is an important factor in this regard. However, in cases of highly



Fig. 345.



Fig. 346.

Fig. 345.—Superficial basal cell epithelioma recurring following cauterization and electrocoagulation.

Fig. 346.—Result in case shown in figure 345 following excision of epithelioma and application of full-thickness skin graft.

malignant epithelioma and with recurring lesions, especially following irradiation, deep infiltration at times takes place early and the possibility of involvement of the bone and of intracranial extension is always present.

Basal cell epitheliomas frequently extend to the scalp from the forehead and temporal region by direct continuity, although they may develop here primarily (figs. 345 and 346). Like such lesions about the upper part of the face, they often are very superficial in type, produce only slight discomfort and progress slowly. At times they tend to beal in their central portion while gradually progressing at the periphery. They may cover a wide area and yet remain freely

mobile because of lack of extension to the galea (figs 347 and 348). However, following incomplete treatment, especially with radiation the galea often becomes involved and perforation of the cranium may occur subsequently.

Epitheliomas of the scalp are best removed surgically. Small, superficial lesions may be electrocoagulated or excised and the wound sutured. Larger lesions, if freely movable, may be excised sharply or with the diathermy scalpel and immediate skin graft or some other type of plastic repair of the wound performed. Growths that are fixed should be removed by means of electrocoagulation, the underlying



Fig 347—Extensive basal cell and squamous cell epithelioma, grade 2 re-

347 three years following excision
 of the grafted area resulted
 from uncovering the bone during removal of the epithelioma. This sequestrum
 was removed subsequently and the defect was repaired with a pedicle scalp flap.

bone thoroughly cauterized and irradiation used to supplement this treatment. The radiation may be applied as radon implants inserted into the margins of the wound, as radium tubes wrapped in gauze and placed in the wound, as radium packs or as roentgen therapy. In this connection the necessity of making careful roentgenographic studies of the skull prior to advising treatment for any fixed tumor in this situation cannot be overemphasized. A word of warning in this regard has been sounded by Camp, who observed that seemingly innocent nodules of the scalp frequently are expressions of systemic, osseous or intracranial disease.

Neoplasms of the scalp that involve the bone but have not yet extended to the dura should be dealt with in the same manner as the



Fig 349



Fig 350

Fig 349—Deeply ulcerated recurring epithelioma of the scalp measuring approximately 7 cm in diameter

Fig 350—Scalp wound in case shown in figure 349 approximately six weeks following removal of epithelioma



Fig 351—Cranium in case shown in figures 349 and 350 a Prior to operation showing destruction of outer table b Five months later, showing extent of bony loss involving full thickness of skull

group just described. However, in these cases craniotomy should be done and a bone flap extending well beyond the area of involvement

the light of recent experience the brain can no longer be considered insensitive to radiation and added that the reflex changes cerebral hypoplasia, vascular changes and glial degeneration reported in the literature bear ample testimony to this fact

Melano epitheliomas of the scalp are encountered only infrequently. They may develop in the pigmented nevi commonly seen on the scalp or they may be a direct extension from the mastoid or temporal region or from the auricle. They are characterized by the usual features presented by such lesions elsewhere in the body, namely, rapid growth and metastasis. Unless these tumors

are anticipated in most instances removal



Fig. 357—Melano epithelioma of the scalp originating in a pigmented nevus.
Fig. 358—Immediate result in case shown in figure 357 following removal of melano epithelioma and application of full thickness skin graft

type at times is sought by the patient because of the annoyance or the unsightliness of the mass even though the ultimate prognosis is good. The patient seen some years ago who had a large pigmented nevus on the scalp and mastoid region had requested removal of the lesion with her wearing a headphone. Although deep diffuse pigmentation of the posterior wall of the oropharynx was already present removal and skin graft enabled the patient to continue with her work for approximately two years (figs 357 and 358).

Sebaceous cysts of the scalp generally are considered of little consequence aside from their appearance, the annoyance of their presence and the possibility of their becoming acutely infected. While these features furnish sufficient reason for their removal of even greater importance is the likelihood of malignant change developing in them. Cases of epithelioma originating in sebaceous cysts have been re-

ported by a number of writers and several such instances have come under my personal observation. Caylor in 1925 reported a study of 236 sebaceous cysts, a third of which occurred on the scalp, the forehead or the temporal region. Approximately 34 per cent of the entire series eventually became malignant. Of the malignant group three were situated on the scalp. All of them were squamous cell epitheliomas, two being graded 1 and one being graded 3 according to the classification of Broders. Such a tumor early presents as a localized, firm, movable mass and in the majority of instances its true nature is not suspected prior to removal. Enucleation with the capsule intact



Fig 359—Multiple adenocarcinomas, grade 1 (cylindroma), on the face (a) and scalp (b) of a girl nineteen years of age. The tumors had been present since the age of eight years.

offers a good prognosis but incomplete removal is followed by prompt recurrence and ulceration and fixation are likely to occur.

Next to the epitheliomas, *fibrosarcomas* are the most common malignant tumors of the scalp. The exact site of origin of these neoplasms may be difficult or impossible to ascertain definitely. However, since some of them are more or less mobile primarily, while others are firmly fixed, it appears obvious that they may spring from the epicranium, the galea or the more superficial fibrous structures. Such a tumor presents as a symptomless, firm to hard, smooth, nonulcerated, rounded fibrous mass. Growth as a rule is slow and often tends to remain so in spite of repeated recurrence. Frequently these neoplasms are mistaken for simple fibromas because of their inactivity and this

often results in incomplete removal with subsequent recurrence. Although the overlying skin often is involved and becomes thin and tense, ulceration usually does not occur except as a result of trauma. Metastasis is not likely to take place until late in the course of the disease even though considerable inflammatory reaction is present. Most of the tumors of this type coming under my observation have been graded 1 or 2 according to Broders' classification. They have been firm on palpation and either fixed or only slightly movable. The more highly malignant growths have been softer and more vascular than the less malignant growths. Some of them had been mistaken for adenocarcinomas of mixed tumor type. However, these rarely occur on the scalp and they usually possess a definite capsule (fig 359).



Fig 360



Fig 361



Fig 362

Fig 360—Fibrosarcoma of scalp that was recurring following excision and irradiation.

Fig 361—Fibrosarcoma of scalp that was recurring following excision two years previously. A biopsy had been done recently.

Fig 362—Sequester in operative wound in case shown in figure 361 approximately nine months following surgical removal of fibrosarcoma.

Fibrosarcomas of the scalp often are not considered of serious consequence until after they have recurred once or more (fig 360). By that time they usually are firmly fixed to the skull and thorough cauterization of the underlying bone following excision with the diathermy scalpel is necessary in order to insure complete removal (figs 361 and 362). Supplemental irradiation by means of interstitial application of radon, direct application of radium tubes to the incision, radium packs or roentgen therapy also is advisable. The problem of plastic repair here corresponds to that following removal of epitheliomas of the scalp. With radical removal the prognosis in these cases is good.

Primary lymphoblastoma (Hodgkins disease) of the scalp is ex

tremely rare. Secondary involvement by this condition occurs much more frequently than primary involvement. Greenhouse and Cornell reported a case of primary lymphoblastoma of the scalp. The patient, a man forty years of age, gave a history of trauma to the involved region fifteen months previously. However, this probably had no direct bearing. Examination showed an area of alopecia on the vertex of the scalp on which was a serpiginous, shiny, indurated lesion, the size of the palm, elevated about 0.5 cm. above the surface. This was bluish red and slightly yellowish, freely movable and not tender. There were no subjective symptoms. Microscopic study following biopsy showed Hodgkin's disease. There was no evidence of this condition elsewhere. The lesion of the scalp responded to roentgen therapy.

SECONDARY MALIGNANT TUMORS OF THE SCALP

Metastasis to the cranium occurs much more often than does cutaneous metastasis on the scalp. In fact, the latter is rare. Kaufmann and Wolf reported sixty-five cases of cutaneous metastasis, in only one of which the scalp was involved. Metastasis to the scalp may be secondary to various types of malignant tumors of different portions of the body. However, some forms of neoplasms and especially those of certain organs are particularly prone to metastasize to the skull and scalp. One of the chief offenders in this regard is hypernephroma, which at times will produce a metastatic tumor in this situation before symptoms referable to the genito-urinary tract appear. Highly malignant neoplasms of any portion of the body may metastasize to the scalp. Such extension from carcinomas of the stomach, colon, breast, bronchus and prostate has been reported. In some instances these tumors of the scalp were misdiagnosed as sebaceous cysts or other benign growths, since the primary malignant process had not yet attained sufficient size to permit recognition. Multiple myelomas frequently involve the cranium and they may secondarily invade the scalp.

Most metastatic growths on the scalp are seen as a small solitary nodule or several small nodules. However, they may be very numerous and produce a huge turban-like tumor, as in the case presented by Ronchese and that of Sequeira. In the former case, in which the patient was a man, sixty-nine years of age, there had developed during the course of sixteen months multiple firm, pink, slightly mobile tumors ranging up to 3 or 4 cm. in diameter, which were so numerous that they literally covered the scalp. A half-dozen small nodules were also present on the back, thorax and abdomen. Necropsy revealed the condition to be part of a generalized metastasis from a carcinoma of the prostate. In the case reported by Sequeira metastatic growths on the scalp which were secondary to a chondrosar-

ated oo, is approximately 1,500 Only those described herein had been diagnosed as lymphosarcoma or some other malignant neoplasm closely resembling lymphosarcoma but indistinguishable from it for reasons such as infection and therapy

In this series of nineteen patients who had primary lymphosarcoma of the orbit, four are known to have been alive and well for five years or more, at the time of writing One of these four patients has been alive eleven years, another, nine years, the third six years and the fourth five years Five patients have been treated within the past two years (1944 and 1945) and are considered to have been seen too recently for evaluation of their condition All five were well at the time of writing Six patients are known to be dead, four of these died as the result of the tumor and two died from accidental causes Four patients have not been heard from recently, but it is known that three of these were alive at least two years, and that one was alive one month, after treatment Of those patients who died as the result of the tumor, the average time of survival after treatment was nineteen and a half months

Reese reported the results of treatment of five patients who had lymphosarcoma of the orbit The average age of the patients in his series was fifty five years Three of the patients died before two and a half years had elapsed since treatment Two were alive at the time the report was published, one of these had lived three years, and one had lived two and a half years, after treatment Sisson reported on a patient who was alive and well eight years after exenteration of the orbit and roentgen ray therapy Woodson described a probable lymphosarcoma which disappeared after irradiation Gross and Votava wrote of a bilateral retrobulbar lymphosarcoma which regressed after irradiation but the patient subsequently died

In our series surgical removal of the orbital tumors was performed for twelve of the nineteen patients three patients underwent exenteration of the orbit For the remaining four patients biopsy was carried out All patients received some type of radiation therapy after the operation Twelve patients received radium therapy, five had roentgen ray therapy and three received combined roentgen ray and radium therapy In the cases in which exenteration of the orbit was performed, radium was implanted directly in the orbit, whereas in the others it was employed externally in the form of blocks All radiation therapy was administered in the roentgenologic and radium departments of the Clinic The four patients in this series who lived five years or more had undergone surgical removal of the orbital tumor Three of these four patients had received radium therapy postoperatively, the other had received roentgen ray therapy

The histologic picture of these tumors was surprisingly uniform. All presented the characteristics of the lymphoblastomatous type of

lymphosarcoma. The tumors were composed of fairly uniform, closely packed round cells, with little cytoplasm and hyperchromatic nuclei. Cell types differed somewhat according to the degree of malignancy. They were found in a scanty reticulum in no characteristic arrangement. In one case an area of necrosis was present in the tumor, but no other regressive changes were present.

LYMPHOCYTIC TUMORS OTHER THAN PRIMARY LYMPHOSARCOMA

In addition to primary lymphosarcoma of the orbit, a few other lymphocytic tumors of the orbit have been encountered at the Clinic. There are five cases in which secondary lymphosarcoma invaded the orbit. The average age of the patients in these cases was 61.4 years. For four of the five the diagnosis of generalized lymphosarcoma had been made; the fifth patient had lymphosarcoma of the nasopharynx and parotid region. All these patients died. One patient lived two and a half years and died by suicide. The others died one month, three months, seven months and twenty months, respectively, after they had been seen with an orbital lesion.

There were also seven cases of Mikulicz's disease, in which the average age of the patients was fifty-two years. In five of these cases the diagnosis was based on microscopic examination of material removed surgically; in the two other cases diagnosis was based on clinical evidence. All these patients were alive when they were last heard from. In three of these cases the tumors were unilateral. In all but one case the tumors were situated in the upper temporal quadrant of the orbit, and in most instances multiple nodules were palpable. The presenting symptoms of these patients were ptosis or proptosis. Tumors were removed surgically from four patients; for one patient biopsy was performed. All patients received roentgenologic treatment. Three patients experienced exacerbation of symptoms which were treated satisfactorily with additional roentgen rays. One patient did not return to the Clinic; the condition of this patient was followed for only three months. Two other patients were treated within the past year (1945). The condition of the others was followed for variable periods, but the patients were known to be alive and well for from three to eight years.

The condition of a child, two and a half years old, with the presenting symptoms of exophthalmos, was presumed to be lymphosarcoma (Hodgkin's type) or lymphatic leukemia, because of characteristic hematologic observations.

The right eyelid of a man, seventy-two years old, contained a tumor measuring 28 by 22 by 20 mm. It was removed and was found to be definitely a malignant neoplasm; the diagnosis was "nonmelanotic melano-epithelioma" or "lymphosarcoma."

An intraorbital tumor was removed, elsewhere, from a woman,

sixty-five years of age, and a section of it was sent to the Clinic for examination. The tumor rapidly recurred. The woman came to the Clinic for additional treatment. Sections of the original tumor, which had been removed elsewhere, proved to be grade 2 (Broders' method) hemangio endothelioma, whereas the recurrent tumor removed at the Clinic a few months later was diagnosed as "grade 4 malignant neoplasm, probably lymphosarcoma."

MALIGNANT ORBITAL TUMORS ASSOCIATED WITH TUMORS OF THE BRAIN OR SKULL

Malignant neoplasms of the orbit often are associated with tumors of the skull or of the brain. In the case of orbital tumor and tumor of the brain occurring at the same time, it would be presumed that the neoplasms were identical if not actually connected. There may, however, be two distinct processes, as identified by histologic examination. The following case is an example.

An Illustrative Case—A woman, twenty five years of age, came to the Mayo Clinic because of left exophthalmos, displacement downward of the left eyeball and recurrent swelling of the left upper eyelid. At operation the orbit was entered through a brow incision. The roof and lateral wall of the orbit were rough, the periorbita was thick but not adherent to the bone. Beneath the periorbita was a tumor situated along the lateral wall below the lacrimal fossa, and extending toward the inferior orbital fissure. This tumor was firm, not encapsulated, and was surrounded by dense tissue. There were no dehiscences in the walls of the orbit. The tumor, which was easily dissected out, measured 2.5 by 1.5 by 1 cm. The pathologic diagnosis was "Mikulicz's disease." After the operation, proptosis gradually receded until the patient's eye was almost in normal position. Vision was 6/12. Proptosis recurred within two weeks, fluctuated a few days and then gradually increased.

Roentgenograms of the patient's head made before the operation on the orbit had disclosed thickening of the frontal bone on the left side, the lateral margin of the orbit and the greater wing of the sphenoid bone. Repeated roentgenograms confirmed a clinical diagnosis of frontal and basofrontal meningioma. Left trans-frontal craniotomy was performed by Dr. A. W. Adson. Multiple meningiomas were found to arise from the arachnoid side of the dura along the sylvian fissure. Just above the sylvian fissure on the frontal lobe side were nubbins, the largest of which was 2 cm., and the smallest, 5 mm., in diameter.

The extradural surface was covered by a pinkish, sessile mass which was thought to be meningioma but which looked like inflammatory tissue. This mass extended over the dura which covered the left temporal and frontal lobes and part of the parietal lobe and must have been 15 cm. in diameter.

The dura, and the diffuse, heavy, inflammatory mass which contained meningeal tumor cells, extended down underneath the frontal lobe over the roof of the orbit and in turn produced the same hypertrophy of the bone that had been observed over the frontal and temporal areas. The orbit was unroofed dorsally. Then the lateral and inferior walls were removed, including all bone and all involved dura, so that the frontal and temporal lobes and part of the parietal lobe were denuded of dura. The arachnoid was still in place and the brain was not injured, except in two or three small areas in which the nodules had penetrated the arachnoid. These small areas were situated on the inferior and lateral aspect

of the frontal lobe in the premotor area and also in the frontal and temporal convolutions on the left. The bone that was removed appeared to be honeycombed and crumbly in structure, not unlike the bone that sometimes covers a meningioma. The perplexing aspect of the situation was that the periosteum over the frontal and temporal regions appeared to be hypertrophied, and gave the impression that it had been invaded by some neoplasm such as a sarcoma. As a matter of fact, the extradural plaque looked like a sarcoma. After the orbit had been unroofed, the periorbita appeared to be smooth and there was no evidence of the same type of inflammatory structure that had invaded the periosteum on the external surface of the skull. Yet, when the periorbita was incised in the dorsal and mesial aspects, the same sort of hard, edematous tissue was encountered. Dissection was continued and a large portion of the hard, edematous tumor was removed, so that when the operation was finished the superior levator and rectus muscles could be demonstrated. The pathologic report, based on examination of frozen sections was "inflammatory tissue reactionary tissue containing meningeal cells and probably sarcoma." Sections of fixed tissue from the skull, from the orbit and from the tumor of the brain exhibited "diffuse inflammatory reaction with many lymphocytes."

On two occasions during the first five years after craniotomy the wound was opened. Tissue removed on those occasions exhibited only inflammatory reaction. To the time of writing there has been no recurrence.

SUMMARY

Malignant lymphocytic tumors situated in the orbit, as well as elsewhere, present problems of diagnosis, both clinically and histologically. Nineteen cases of primary lymphosarcoma of the orbit have been considered, and brief reference has been made to some other lymphogenous tumors of the orbit. One case in which the intra orbital and intracranial manifestations presented a puzzling problem of diagnosis has been described.

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SELECTION OF PATIENTS FOR THE FENESTRATION OPERATION FOR OTOSCLEROSIS

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THE original impetus which has led to the present fenestration operation was the accidental opening by Bárány of the horizontal semicircular canal while doing radical mastoidectomy on an otosclerotic patient under local anesthesia. He noted an immediate improvement of the patient's hearing. As a result of this observation in 1907 Bárány made an attempt to produce a labyrinthine fistula within a patient who had otosclerotic deafness. Improvement of hearing lasted for a few days only. Again in 1913 in two cases Jenkins made fistulas into the horizontal canal and covered them with skin grafts. He obtained immediate good results as far as hearing was concerned but one patient soon became completely deaf in the ear on which the operation had been performed and the hearing of the other soon returned to the preoperative level.

In 1917 Holmgren initiated the long series of trials that may be said to have led to the present technic of fenestration. He finally developed the following technic. While the patient was under local anesthesia wide antrotomy was performed and fistulas were made with a chisel into the horizontal and posterior vertical canals. The eodosteum was removed without injuring the membranous labyrinth. Holmgren noted that as soon as a fistula had made even the smallest opening into one of the canals reducing perilymphatic pressure the hearing immediately approached normal. After the fistulas had been formed a prosthesis of fat was placed in the antrum to try to prevent their closure. In Holmgren's and previous technics it seems evident that the surgeon attempted to secure a constantly filtering scar similar to that obtained in the trephine operation for glaucoma. Holmgren reported operations on thirty four patients with various modifications of this technic. Of these thirty four cases Holmgren stated that restoration of hearing persisted to a worth while degree in eight cases (24 per cent). Holmgren observed however that in many cases the hearing in the ear on which operation had not been performed became progressively worse but in the ear on which operation had been performed the hearing remained stationary. Even though Holmgren selected the worse of the two ears to be operated on and the operative result was an apparent failure after several years the ear on which operation had been performed became the better in nearly all instances.

Sourdille^{12 13 14} after observing Holmgren's work developed a pro-

cedure, depending on a new principle which he termed tympano labyrinthopexy. The operation was done in three stages. In the first stage the integument was removed from the posterior superior wall of the external auditory canal so that it might be replaced by a thin flexible scar. After epidermization of the scar at a second operation the mastoid process was completely exenterated and the heads of the malleus and incus were exposed. The malleoincudal joint was then opened and the head of the malleus was removed. After epidermization of the operative cavity, the third stage of Sourdille's operation consisted in lifting up the endomastoid flap at the level of the horizontal semicircular canal making a fistula in the canal and covering it with the thin scar produced by the two previous procedures. Sourdille usually found it necessary to lift the flap two or three times and remove bone newly formed by the periosteum and endosteum before the fistula could be maintained permanently open. The long delay between the various stages of this procedure was necessitated by infection in the incision following the various stages, repeated operations over a period of two years or more being required.

Sourdille's technic proposed a new concept however. Instead of endeavoring to secure increased mobilization of the perilymph and endolymph by producing a constantly filtering scar, which when attained resulted in eventual labyrinthitis with complete loss of hearing, Sourdille hoped that a thin epithelial flap over an open fistula would give enough extra mobility to the endolymph so that, with the increased excursions of the tympanic membrane produced by excising the head of the malleus, sound wave striking the drum which was attached to the scar covering the fistula would be transmitted with magnified force to a more mobile perilymph.

Sourdille reported operation on 109 patients having otosclerosis with hearing apparently restored to normal conversational levels in 40 per cent. There was moderate to slight improvement in the hearing of the remainder. He did not report any cases in which the hearing had been made worse by the procedure.

In 1938 Lempert⁷ proposed a one stage technic utilizing the principle suggested by Sourdille by which a fistula or fenestra made in the horizontal semicircular canal could be immediately closed with a thin pliable flap of the meatal integument still attached to the margin of the intact drum. The Lempert⁸ technic made feasible for any patient an operation that had been economically impossible previously for any but a few. It was with the introduction of the Lempert single stage technic that the fenestration procedure was lifted out of the class of purely experimental surgery and put on a practical footing. To Lempert therefore rightfully belongs the title of father of the present surgery for functional disorders of the organ of hearing.

Lempert⁹ has further modified his technic from time to time so

that at the present time after the mastoid cell structure has been extirpated, the incus is removed and the head of the malleus is cut off. A flap is then fashioned from the integument of the posterior and superior wall of the external auditory canal, the thinnest portion of which attached to the tympanic membrane is to be placed over the fistula, which is fashioned at the junction of the horizontal semicircular canal with the labyrinth. After the fistula or fenestra has been made, it is filled with a "stoppie" fashioned from cartilage or other substance neither provoking nor taking part in bodily reparative processes. The stoppie may be loosely fitted so as to vibrate or may be perforated so as to admit sound waves. The purpose of the stoppie is to stop regenerating bone from the periosteum from filling the newly formed fenestra and to protect the delicate membranous labyrinth from reactive labyrinthitis.

Lempert reported that, of 815 cases in which the fenestration operation was done for clinical otosclerosis, complete rehabilitation for social and economic contacts as a result of restored hearing was secured in 571 cases (70 per cent). Of seventy five patients on whom operation was performed more than six years ago, twenty four patients (32 per cent) have maintained practical serviceable hearing.

HOW DOES THE FENESTRATION OPERATION IMPROVE HEARING?

Normally, localization of hearing seems to be produced in the organ of Corti by fluid waves of certain frequency producing a displacement of the basilar membrane on which the nerve cells rest in certain definite areas corresponding to the lengths of the waves entering the cochlea. The cochlea is a rigid bony tube 32 mm. in length when uncoiled. It is divided into three tubes. The central tube, the cochlear aqueduct, is closed at the upper end but communicates at the lower end with the sacculle. It contains endolymph, which bathes the organ of Corti. The other two spaces, the scala vestibuli and the scala tympani, are connected through the terminal coil by a narrow opening termed the helicotrema. They thus form a continuous tube closed at one end by the elastic membrane of the round window and at the other by the foot plate of the stapes and its annular ligament.

The tympanic membrane and the set of three levers called the ossicles connecting it with the foot plate of the stapes are essentially a mechanism for transforming energy in the form of air waves into energy in the form of waves in fluid. Since water is incompressible it is necessary to have a means by which energy entering the cochlea through one opening may escape through another. Waves set up by vibrations of the stapedial foot plate transmit energy along the scala vestibuli through the helicotrema and down the scala tympani where they escape through the elastic membrane of the round window which vibrates in alternate phase with the foot plate of the stapes.

It is apparent, therefore, that if either of the openings from the middle ear into the cochlea becomes so rigid that it is incapable of transmitting energy into or out of the cochlea, energy waves entering the cochlea will be unable to produce any deformation of the basilar membrane, the nerve cells of the organ of Corti will not be stimulated and central transmission of the form of energy known as sound will be lacking or deficient. If growth of new bone as in otosclerosis fixes the foot plate of the stapes or the mobility of the round window is impeded, as is frequently the case following inflammations involving the middle ear, hearing will be reduced.

Holmgren noted that, if the slightest leak of perilymph occurred in performing operation on the labyrinth with the patient under local anesthesia, the hearing was immediately increased, even though a fenestra had not been completed. He concluded therefore that the increased mobilization of the perilymph was the factor that led to the immediate increase of hearing noted at the operating table.

Sourdille enlarged on this notion and pointed out that, when an opening was made into the labyrinth, perilymph above this opening immediately ran out, leaving all the spaces above the level of the fistula empty and so forming a free surface of perilymph responding to vibrations with a greatly increased intensity. In Sourdille's opinion it was the greater mobility of the perilymph produced by the reduction of pressure in the labyrinth and the formation of a free surface of perilymph that produced the immediate spectacular gain in hearing once the labyrinth was fenestrated. He pointed out that the rapid reduction of hearing following the operation was owing to the refilling of the labyrinth with perilymph. He felt therefore that the surgical problem presented for solution was the development of a method for preserving an increased mobilization of the perilymph in a filled labyrinth. He felt that this could be done by covering the fistula made in the labyrinth by a permanently elastic covering attached to the edge of a tympanic membrane whose excursions when stimulated by air waves would be increased by the resection of the head of the malleus.

This principle established by Sourdille is the one followed by Lempert in his improvements and modifications of the technic. That it is correct seems to be substantiated by the conclusions drawn by Lempert from a study of his first 1,000 cases in which operation was performed.

It would follow from the hypothesis given in preceding paragraphs that to secure good results from the fenestration procedure the tympanic membrane must be able to vibrate and the nerve cells in the organ of Corti must be in a condition to receive and transmit the normal stimuli. Conditions interfering with the mobility of the tympanic membrane are: (1) perforations or other conditions producing

flaccidity, (2) adhesive bands preventing motion of the tympanic membrane or ossicular chain, (3) any condition interfering with the pressure relationships on the two sides of the tympanic membrane. Conditions interfering with reception of stimuli by the organ of Corti are (1) degeneration of the nerve cells of the organ of Corti (2) degeneration of the nuclei and association centers in the cerebrum (3) closure of one or both windows

SELECTION OF CASES FOR THE FENESTRATION OPERATION

Otosclerosis.—The fenestration operation is designed to correct loss of hearing produced by otosclerosis, since it is not probable that deafness produced by any other type of pathologic change in the ears can be corrected by surgical procedures at the present time. Otosclerosis, however, is a histologic diagnosis that cannot be made with absolute certainty on the living person. Therefore patients on whom the fenestration procedure seems advisable are said to have "clinical otosclerosis," meaning that, so far as the clinician can tell within a reasonable margin of error produced by the difficulty of making an exact diagnosis in the living, the deafness in the patient under consideration is produced by the otosclerotic process.

Some facts having a bearing on the selection of patients for the fenestration procedure that have been brought out by Fowler and by Guild in his study of histologic otosclerosis should be mentioned here. Fowler found that while one of twenty necropsies on adults showed otosclerosis in less than a fourth of the cases in which otosclerosis was present the disease had invaded the annular ligament of the stapes and resulted in loss of hearing. In the study of serially sectioned temporal bones secured at random Guild found forty nine cases of histologic otosclerosis in only one of which the patient had been less than five years of age and in only six of which the patients had been less than twenty years of age. In the age group of thirty to forty nine years there were twenty seven persons who had otosclerosis. This suggests that the statement that otosclerosis tends to start at puberty is incorrect since but six of the forty nine patients were less than twenty years of age. Guild stated that the incidence of approximately 4 per cent for the occurrence of otosclerosis in the whole group would be much larger if the material contained the same proportion of whites and of females as does the general population of this country. In forty six cases of otosclerosis in which sections of both ears were available the otosclerosis was bilateral in thirty two cases and unilateral in fourteen cases. This suggests that unilateral deafness may be more frequently produced by otosclerosis than had hitherto been suspected.

In regard to location of otosclerotic regions otosclerosis involved the region of the oval window in sixty five of the eighty one ears and twenty five of the eighty one ears had an otosclerotic region at some

part of the attachment of the round window. There were in all forty-eight otosclerotic areas not in the region of the oval window. Guild stated that without exception, the material on which this report is based is in agreement with the opinion that otosclerosis does not cause an impairment of hearing until or unless a booy connection becomes formed between some part of the margin of the oval window and the stapedial foot plate. The stapediovestibular articulation had become ankylosed in only ten of the eighty-one ears in which there was histologic otosclerosis. In the region of the oval window in the sixty-five ears studied the otosclerotic process was active in thirty-two ears and quiescent in thirty-three ears but in all the cases in which stapedial ankylosis had occurred the otosclerotic process was of good size and active. In none of the cases in which otosclerotic processes involved the region of the round window had the disease progressed to the point at which hearing was affected.

This material enables one to answer several questions in regard to the advisability of the fenestration operation in cases of loss of hearing presumably secondary to ankylosis of the stapediovestibular articulation. 1. Is the involvement of the round window likely to make a good result from the fenestration procedure impossible? 2. Is progression of the otosclerotic process likely to compromise the organ of Corti and so vitiate the result obtained by fenestration? 3. In a case of early clinical otosclerosis is quiescence of the process probable before such serious impairment of the hearing takes place that hearing aid will become necessary? 4. Does the absence of a family history of deafness, even when well authenticated, make the diagnosis of clinical otosclerosis less probable? From the material presented it seems logical to conclude that these questions should be answered in the negative.

Another question frequently asked concerns the possibility of inheritance of otosclerotic deafness. Guild stated that the facts in the material presented rendered invalid all conclusions with respect to dominant and recessive genes that have been drawn from clinical studies of the inheritance of otosclerosis. Since, however, the studies that he mentioned are rather on the inheritance of otosclerotic deafness than on the inheritance of otosclerosis itself, it would seem that the material presented does not invalidate these studies. In this instance Guild appears to have been misled by the confusion of clinical with histologic otosclerosis which he warned against in his paper.

In reviewing data on the patients who have presented themselves at the Clinic in regard to deficiency in hearing it has seemed justifiable to make a diagnosis of clinical otosclerosis in approximately 20 per cent of cases. It can be seen at once therefore that the majority of the deafened cannot be expected to profit by the fenestration procedure. It also seems justifiable to state from our findings that not more than 50 per cent of those patients for whom a diagnosis of clinical otoscle-

rosis can be made are suitable patients on whom to perform this procedure

General Contraindications to the Fenestration Procedure.—Since the fenestration operation is an optional surgical procedure any general condition which might add to the risk of operation should be a contraindication to the procedure. Among such conditions should be mentioned diabetes, severe peripheral vascular disease and malfunction of the kidneys. Since the operation should be considered a major surgical procedure with a moderate amount of surgical shock, advanced years must be considered a contraindication unless the patient is physiologically younger than his chronologic age. The fenestration operation is as a rule not often indicated when a patient is more than fifty years of age because of the degenerative changes in the auditory nerve which are frequently present at this age and above.

Otologic Contraindications to the Fenestration Procedure.—If the disability of hearing appears to be due primarily to degeneration of the auditory nerve it is obvious that the fenestration procedure offers nothing. If however there appears to be a combination of clinical otosclerosis with atrophy of the cochlear nerve fibers an attempt must be made to judge how much of the deafness depends on the otosclerotic process and how much on the degenerative change of the nerve, since too great a degree of nerve deafness is a contraindication of the procedure. This is by no means a simple task in some instances because some patients exhibit a tendency possibly subconscious to lead the diagnostician astray. When degeneration of the nerve has been present for some time many patients tend to confuse sound with the vibratory sense and will report prolonged bone conduction when in fact it is definitely shortened. The fork should be tested on other bony regions of the body, preferably the knuckles, to make sure that the patient is properly distinguishing sound from vibration.

In testing for bone conduction on the audiometer with the bone conduction receiver, as Grossman and Molloy have pointed out, owing to physical difficulties with the bone conduction receiver the position of the bone conduction curve is of little significance, providing it is not significantly lower than the air conduction curve. However the shape of the bone conduction curve is of definite significance. Bone conduction testing with the audiometer above 1,028 double vibrations per second is without significance, but if the bone conduction curve shows a tendency to drop sharply at this frequency or lower, or if there is a drop in the middle frequencies, these changes are significant of atrophic changes affecting cochlear cells responding to the speech frequencies. Losses above 2,048 double vibrations which appear to be owing to nerve degeneration will not greatly affect the immediate result to be obtained from operation, but whether the fenestration

operation tends to prevent further hearing deterioration of the perception type is a debatable question

As an example of the effect of early cochlear degeneration I would state that if in a patient with evidence of a combination of clinical otosclerosis with atrophic changes in the nerve fibers or of the organ of Corti the air conduction curve drops sharply above 2,048 double vibrations per second and if in the speech frequencies the au conduction curve is below the 50 decibel line the patient should be informed that the probability of obtaining a worthwhile immediate result (restoration of hearing to conversational levels for at least four months) from the fenestration is not more than 30 per cent with the expectation that in about a third of the cases in which the operation is primarily successful, hearing will drop to the preoperative level owing to bony closure of the fenestra. It is evident that the good results obtained vary directly with the amount of nerve degeneration apparently present

Guild stated that, since the cause of cochlear atrophy in ears without otosclerosis cannot be established in most cases, it therefore does not seem logical to attribute to otosclerosis all the cochlear atrophy found in otosclerotic ear. In spite of Guild's statement there seems to be a more marked increase in clinical evidences of such changes among patients who have clinical otosclerosis than among people in the same age group without clinical otosclerosis. On theoretical grounds this might be ascribed to cochlear degeneration secondary either to immobilization of the perilymph and endolymph or to elimination of the protective function of the structures of the middle ear against acoustic trauma, particularly the damping effect of the stapedius and tensor tympani muscles. If the first hypothesis proves to be correct, the fenestration procedure might be expected, if successful, to prevent further deterioration. If the second hypothesis proves to be correct, the fenestration procedure should render the cochlea more vulnerable to acoustic trauma than it was before the operation. That the fenestrated ear is much more subject to auditory fatigue than the normal ear has been observed in certain of my own successful fenestrations.

The "selected group" of clinical otosclerotic patients, that is, those patients who have clinical otosclerosis and no evidence of degenerative changes in the organ of Corti, do not make up more than approximately a third of those patients diagnosed at the Clinic as having clinical otosclerosis. I believe that this fact should be remembered, when one is considering statements in regard to results obtainable among the "selected group" of otosclerotic patients. While patients not in the selected group may properly undergo the fenestration procedure, they should understand that the probability of a successful result is definitely lessened in a degree dependent on the amount of

nerve degeneration apparently present and the surgeon should insist that the patient share responsibility for the operation

THE DIAGNOSIS OF CLINICAL OTOSCLEROSIS

The diagnosis of clinical otosclerosis is one that must be made by exclusion

Differentiation from Perceptive Deafness—A loss of hearing of insidious onset starting between five and forty years of age is in most instances the result of histologic otosclerosis, especially when an authenticated family history of inherited loss of hearing can be obtained. However, this is not invariably the case. At the Clinic my colleagues and I have encountered several instances of so apparently inherited deafness starting in childhood or youth, with a definite family history embracing three generations in which findings indicated perceptive deafness to be present in two of the generations. In such a group careless testing for bone conduction with the tuning fork would be likely to be misleading because of the tendency for such persons to confuse the vibratory sense with the sense of hearing.

Other conditions which will produce perceptive deafness come on insidiously in youth or early middle life are myxedema or lowered basal metabolic rate without myxedema, tubotympanitis and endolymphatic hydrops. The last two conditions are more difficult for differential diagnosis when vertigo has not been produced by the disorders than when vertigo is present.

While theoretically it should be easy to distinguish a conduction deafness from a perceptive type, this is by no means the case especially when an overeager patient feels that a fenestration operation might help him because he has assured himself by reading articles in the lay press that he has "exactly the kind of deafness that the fenestration procedure might help." In cases of long standing tubotympanitis whether on an endocrine or on an allergic basis, organization of the subepithelial exudate seems to take place with permanent physical narrowing of the tube. In many of these instances tubal blockage may be merely physiologic and the tubes may inflate without difficulty. While theoretically an immediate improvement of hearing following inflation should be obvious in such a case it does not always prove simple to demonstrate improvement to the examiner's complete satisfaction. Following serous otitis media which is often associated with tubotympanitis it seems probable that organization of exudate in the middle ear may take place, so that the loss of hearing does not present the drop in high tones with decreased bone conduction characteristic of tubotympanitis but rather presents the characteristic findings of conduction deafness.

Differentiation from Other Types of Conduction Deafness—Repeated attacks of subacute catarrhal otitis media may produce

bands of adhesions particularly involving the round window, without it being possible to obtain an adequate history from the patient suggesting such involvements. This, with the possible exception of allergic deafness, is probably the most common source of error in the diagnosis of clinical otosclerosis. Dullness and retraction of the drum may suggest such a cause for loss of hearing but a drum that appears normal is by no means invariably present in cases found at the operating table to have definite fixation of the stapes and later on to have had an excellent response of hearing to the fenestration procedure. In addition to this there seems to be no particular reason why in a case of histologic otosclerosis scarring of the drum and deposit of scar tissue in the middle ear should not develop as easily as in a case in which histologic otosclerosis is absent. It is known that many patients who have evidence of previous inflammations in the middle ear have perfectly normal hearing in so far as tests are able to demonstrate. There is no good reason, therefore, why a person for whom a presumptive diagnosis of clinical otosclerosis can be made should be refused surgical treatment because of the presence of scarring of the tympanic membrane. It would not seem proper, however, to classify such a person in the "selected group."

If all other causes of deafness can be eliminated within a reasonable margin of error the condition may properly be diagnosed as clinical otosclerosis."

Method of Testing.—The pure tone audiometer alone cannot be relied on for making a differential diagnosis of the type of deficient hearing present. The pure tone audiometer is a mechanism by which what the patient cannot hear is tested rather than what he can hear, since the estimation is of the threshold of hearing. It has, however, some advantages over the speech audiometer, since comprehension of speech takes in a much wider field than hearing and the comprehension as well as the hearing is being tested with such an instrument as the speech audiometer. It may be rightfully stated, however, that without adequate comprehension hearing ability is of minor value. A useful combination of a speech and pure tone audiometer is already being developed and may soon be ready for clinical use. In testing patients postoperatively it should be kept in mind that conversational speech is rarely heard at threshold level. Lowy has given experimental evidence that tone reception following a fenestration operation is heard better and better above threshold level up to the levels of painful loudness. This finding has been confirmed by Walsh in testing the postoperative hearing of patients. Testing at threshold with a pure tone or speech audiometer therefore may give a false impression of the benefit that has been derived from the fenestration procedure. Testing with a speech audiometer above threshold levels would seem to be a more adequate method.

I do not believe that much additional accuracy is to be gained by audiometric testing in a soundproof room, especially if in testing in a quiet room a masking device is used, as it should be, in the opposite ear. A well fitting ear piece will exclude most of the extraneous noise originating in an ordinarily quiet room. The audiometer is an instrument with a relatively wide margin of error, depending as it does on the subjective response of the patient. It is probably conservative to estimate a margin of error of 5 decibels. Therefore even with a sound proofed room little additional accuracy in determination can be obtained.

Greater accuracy in estimating the threshold of hearing is obtained if the point at which the sound is first heard is taken. An attempt should be made to do the testing as rapidly as possible in order to avoid the effect of wavering attention.

In testing bone conduction with the audiometer, because of the defects in the instrument too much attention need not be given to the decibel level at which the curve lies. However, the shape of the curve as stated previously, should bear considerable weight.

Testing with Tuning Forks—As has been stated previously, the estimation of the bone conduction with the tuning fork is of great importance but it must be done with care and the appreciation of the fact that patients both consciously and unconsciously mislead the examiner in their replies. Of the tuning fork tests Lempert's modification of the Schwabach test is the most valuable. This test is done with forks of the four frequencies 256 d v, 512 d v, 1024 d v and 2048 d v with a masking device used in the ear opposite to the one tested. After being struck, the fork is held to the ear being tested and as soon as the sound is no longer heard by air the fork is placed on the bone and the length of time the fork is heard longer by bone than by air is estimated. To be suitable for fenestration the patient should hear the 256 d v fork ten to fifteen seconds longer by bone than by air, the 512 d v fork five to eight seconds longer by bone than by air and the 1,024 d v fork three to five seconds longer by bone than by air. Although Lempert advised testing with the 2048 d v fork estimating bone conduction at this frequency is so difficult that I have found it of doubtful value. Lempert expressed the belief that by this method the "auditory reserve" or the capability of the ear to be restored to normal hearing is estimated and that if the tested ear falls below these values the case becomes increasingly unsuitable for fenestration in proportion to its failure to meet such a test.

Macfarlan expressed the belief that it is impossible to determine how well a person hears speech from a frequency audiogram. He advised the use of a speech audiometer and word testing. Lempert also expressed the opinion that hearing the spoken voice is the final test and that if a patient with an audiogram showing the loss of hearing

along the 50 decibel line, and apparently demonstrating good bone conduction by forks, cannot hear the spoken voice at a distance of more than 2 feet (61 cm.) such a patient has probably been successful in misleading the physician in the other tests and actually has a perceptive deafness. In other words the findings by fork tests, by audiometric testing and by testing with the spoken voice must all agree before the patient can be considered suitable for the fenestration procedure.

If there is a great discrepancy between the hearing in the two ears a caloric test should be done to rule out the effect of labyrinthitis in the worse ear. When great discrepancies exist between the two ears it is impossible to rule out bone conduction to the better ear even with masking.

If there is a great variation between the findings with the audiometer and with tuning forks, provided both tests have been carefully done, or if there is marked variation in tests done on two successive occasions, preferably on successive days, the probability is great that the patient has perceptive deafness.

PROBABILITY OF A SUCCESSFUL RESULT OF THE FENESTRATION OPERATION

If in a given case the bone conduction by fork testing is prolonged ten to fifteen seconds or more beyond the air conduction in the 512 d.v. frequency and eight to ten seconds beyond the air conduction in the 1,024 d.v. frequency, and the audiometric curve does not show evidence of cochlear atrophy and there is no visible evidence of deposit of scar tissue in the tympanic membrane and a presumptive diagnosis of clinical otosclerosis can be made, the probability of such a patient getting an initial restoration of the hearing to a level at which he is under no handicap in hearing normal conversation is about 70 per cent of cases in which operation is performed. This constitutes the so-called selected group. It should be remembered that about 10 to 15 per cent of those securing an initial good result will experience closure of the fenestra sooner or later.

If in a given case a presumptive diagnosis of clinical otosclerosis is made and the patient meets all criteria for the selected group except that evidences of scarring are present in the drum of the ear to be operated on, the probability of securing an initial good result may be estimated at 60 per cent.

If in a case of clinical otosclerosis evidence of cochlear degeneration is found but this does not appear to involve the speech range and the loss of hearing nowhere falls below the 50 decibel line, a 50 per cent probability of a good result may be fairly estimated if no other unfavorable conditions are present. When evidences of nerve degeneration are present, however, the probability of a reactive labyrinthitis

resulting in severe loss of hearing as the result of operation is increased

If in a case of clinical otosclerosis degeneration of the cochlea above the speech range seems apparent and the hearing curve is down to the 60 decibel level or below, in my opinion a 30 per cent probability of an initial good result may be estimated

If evidence of nerve degeneration appears to involve any of the frequencies in the speech range no more than a 15 per cent probability of a good initial result should be offered

There would seem to be little or no justification for operating if the otosclerosis is unilateral, both because such patients are under little or no economic disadvantage and because the probability of error in diagnosis is increased in such a case

To sum up the fenestration operation may be properly done in a case of progressive conduction deafness with little or no evidence of degeneration of cells or fibers of the organ of Corti and no evidence or history of otitis, providing the patient understands the percentage probabilities both of restoration of hearing and of failure to restore hearing and also the possibility of increased loss of hearing in the ear on which operation is performed. Except for a small chance of worsening the hearing by the fenestration operation the patient has lost little by the operation even if it is unsuccessful. As Holmgren pointed out, even an unsuccessful operation tends to stop the progress of the pathologic process in the ear operated on. Even if the most conservative estimate of good results to be found in the literature, which is Lempert's estimate of 32 per cent continued restoration to conversational hearing among the patients on whom operation was performed six years or more previously, is taken as the best obtainable result, the procedure seems well worth while. It can be compared favorably in its results to those obtainable by the operation for detached retina.

Many surgeons have given more encouraging reports than this but no other surgeon than Lempert can report a series of six year cures. For instance 250 fenestration operations have been done at the Clinic but, since in none of the cases have more than two years elapsed since the operation, I think reporting of results would be premature.

With the advance in technic and good end results that will take place with so many otologists working on the problem I think that we can feel sure that the Lempert fenestration procedure has gained a permanent position in otologic surgery.

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SKIN GRAFTING METHODS AND THEIR INDICATIONS

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WHEN a deformity, defect or diseased area requires some type of skin for proper correction, it may be simple to decide how and where to obtain that skin. On the other hand, most of these conditions may be corrected by several methods and it is not always easy for the surgeon to decide which method to use.

On the face, the final cosmetic appearance to be obtained is the decisive factor in the choice. On the hands and feet and about the joints, function is the decisive factor. On the torso and extremities, the chief aim is to restore comfort by expediting healing. The nature and location of the defect, status of surrounding tissue, availability of donor areas, color index and texture of the skin to be grafted, age, sex, mental and social status, time factor, financial position and general physical condition are important factors and should receive thoughtful consideration before any decision is made. In the final analysis each case is an individual problem and because a certain procedure is recommended in one case it does not necessarily follow that it will be the best for all cases that on first consideration seem to be similar. Gillies has said, "It cannot but be admitted that this decision as to the method of treatment is one of the most troublesome that can face either surgeon or physician. Should the ideal be attempted with considerable risk? Should the next best be carried out with less risk? Or should an inferior result be aimed at with hardly any risk?"

The surgeon must first decide whether to use neighboring skin or bring it from a distance. Rotating or sliding flaps, multiple excision and Z plastic operations all will bring neighboring skin into the area in which it is needed. If distant skin is to be utilized then the free graft or pedicle flap is to be used. The free graft may be a full thickness graft, thick split graft, thin split graft or one of the pinch grafts. The pedicle flap may be tubed or open. It may be transferred to the defect immediately or the transfer may be delayed. The transfer may be made in a single stage or in multiple stages.

TYPES OF GRAFT

Grafts from Adjacent Areas.—Adjacent skin must have good blood supply and elasticity. These are of prime importance in determining the success of any procedure which utilizes skin bordering the defect. Long continued radiation, actinodermatitis and dense scarring notoriously reduce elasticity and vascularity and may make the tissues so firmly adherent that any attempt to use them in reconstructive sur-

gery would be folly. Sometimes vascularity of neighboring flaps must be increased by delaying the transfer. This is particularly true if the flap is to be a long one with a narrow pedicle or if the flap is 'skin thin'. Even a small skin flap may have to be delayed if the base is scarred or if there will be much rotation or torsion of the pedicle. Elasticity cannot be increased by delay, however, and the lack of this one quality might ruin the whole procedure by bringing about closure under tension.

The proximity of the available neighboring tissue to a natural orifice must be considered also. If the donor area is too close to an eye or nostril, the torsion may produce a secondary deformity worse than or equally as bad as the first. This is particularly true if the defect is large. In the repair of defects about the lips, this proximity may be a blessing, however, because of the ease with which it lends itself to procedures such as Estlander's operation and its modifications.⁴

The size of the defect too is of great importance if a lining or a large part of fat is required. If the defect is large and turned in, lining may create a raw area that cannot be covered with adjacent tissue. In these instances a free graft or pedicle graft may have to be sutured in to cover the lining and its former bed. Small defects near the eye or nostril that require a lining may be closed satisfactorily if the procedure is carefully planned and executed.

Smith has used neighboring skin to repair almost half of the free with good results. If adjacent skin can be used without increasing the deformity and a good cosmetic and functional result can be obtained, it certainly is the procedure of choice. No doubt it will furnish the best color and texture and hence no tanning, tattooing or make up will be necessary. It has definite limitations, however, which should not be ignored in an attempt to save time or money. If the limitations are not considered, time and money may be lost. Certain circumstances, such as inadequate elasticity, poor blood supply or a large defect, may make it imperative that skin from a distant source be used. If skin from a distant source is to be used, a choice must be made between a free graft and a pedicle graft and any decision must necessarily depend on the surgeon's predilection and experience.

Free Grafts—The free graft has a large field of usefulness. It may be used as a permanent or temporary covering after surgical excision or incision to correct contractures or ectropions, as a substitute for lost or congenitally absent mucous membranes, to provide linings for flaps which need two layers of skin or as a permanent or temporary covering for granulating surfaces following burns, avulsions or chronic infections.

Full thickness Graft—The dissected full thickness graft taken from behind the ear or from the upper eyelid is the finest graft available.

for any small clean surgically excised or incised wound on the face that cannot be corrected by using adjacent tissue. If the wound follows the removal of an active malignant neoplasm it is usually best to wait at least a year, however, before any grafting is done.

If the defect on the face or neck is larger than 4.5 to 5 cm. by 2.5 to 3 cm. it is best to obtain skin from the supraclavicular region, inner aspect of the arm or, rarely, from the abdomen. In women, the first two donor areas may cause objectionable scarring. The full thickness



Fig 363—*a* Ectropion of the lower lip with thickened scars of a woman twenty five years of age who was burned about the face, thorax and arms nineteen years before. In this type of case we feel that it is best to remove excess mucous membrane and make a new margin rather than to attempt to dissect it up and set it back inside the lip. A new vermilion margin is made after excision of the mucous membrane and scar. A full thickness skin graft is taken from back of the ear to replace it. The color of the skin graft is the same as the rest of the face. Pressure for the graft is obtained by leaving the ends of the silk sutures long and tying them over fine mesh gauze with cotton. The teeth are wired together and the patient is fed through a catheter and funnel in order to immobilize the lip. *b* The patient just following removal of the sutures. The new vermilion margin may be noted.

graft from the postauricular region or the upper eyelid gives the most nearly perfect matching for color and texture with minimal scarring in the donor area, and it should be used when at all possible in preference to the supraclavicular graft or a graft from the arm. Full thickness grafts are used most frequently to correct small constrictures and ectropions because of their resistance to postoperative contracture (fig 363 *a* and *b*). The excellent match of color makes them suitable for the face and their flexibility and resistance to trauma is a decisive factor in their use about joints, hands or feet.

It is said that the full-thickness graft is less likely to take than a split-thickness graft. This has not been so in our experience but we have noted that superficial areas of necrosis or deep blisters are occasionally seen in the former type of graft. The full-thickness graft has to be dissected from the donor area with great care and has to be used only in a surgically clean field. It is somewhat limited as to size,



Fig. 364—*a*, *b* and *c*, Huge nodular tumor covering three fourths of the entire scalp. The nodules varied in diameter from 0.5 to 2 cm with hair growing between them. Clinically the tumor was a neuromole. It was impossible for the patient to keep the scalp clean. The pictures were taken in the operating room after the hair had been shaved.

and attention to technical details, such as hemostasis, pressure and immobilization, must be great. The donor area must be closed, grafted or permitted to close by scar epithelium. In addition the postoperative care of the graft may be prolonged, particularly if it is of any size. These are all definite disadvantages and limitations and it may be necessary or wise to use one of the split grafts with which less risk is involved.

The full thickness hair bearing graft usually removed from the scalp in the mastoid region is used to restore part or all of the eyebrow



Fig 365—*a b* and *c* Same case as figure 364. It was thought advisable to remove the tumor first and replace it with skin grafts and later graft a band of hair bearing skin in the region where the hairline would be so that the patient would have hair to brush back over the grafted area.⁵ Due to the extent of the tumor the removal of the neuromole and replacing it with a skin graft were done in two stages. That part of the tumor anterior to a line drawn perpendicularly above the ear was removed and replaced with medium thickness shaved grafts taken from the abdominal wall. The postoperative results are shown above. In applying these grafts it is not necessary to use any adhesive preparation as grafts of the scalp are successful when ordinary methods are used. Vaseline fine mesh gauze was used directly over the grafts and pressure was applied with gauze and adhesive. A hair bearing flap is being made to make a hairline on the right side of the forehead so that the patient can cover the scalp with her own hair

quickly, but in our experience a pedicle flap from the temporoparietal region has been used to greater advantage.

Thick split Graft—The thick split graft (deep intermediate) has more of the good than of the bad features of either the full thickness or the thin split graft (superficial intermediate). An amazingly large thick split graft can be removed from the abdomen or thigh quickly and easily with the Padgett Hood dermatome or the Blair knife. This type of graft is more likely to take perfectly than the full thickness



Fig 366—*a* A girl seventeen years of age who had marked scarring of the left side of the forehead, upper lip and cheek with a scarred band in the left inner canthus. The skin surface was irregular and pitted and resulted from radium treatment of an angioma. Even when such cosmetics as powder or paste were used an uneven surface remained and looked bad. It was thought best to correct this deformity by means of thick shaved grafts in order to make a smooth surface so the patient could apply cosmetics. The web-shaped scarring in the inner canthus was corrected by means of a Z plastic. Skin grafts were removed from the inside of the right leg and after excising the scar on the left side of the forehead, left cheek, left side of the upper lip and parotid region on the left side, grafts replaced the raw surface. *b* Six months after the skin graft. The patient was able to cover the defect with cosmetics as the surface was perfectly smooth. The slight white line between the skin graft and the upper lip and cheek could be corrected but the patient felt that she was quite happy about the result as it was and did not wish anything further done. The result is very satisfactory and the deformity type of procedure fits

graft in fields which are not entirely clean. It has a good resistance to contracture, postoperative care is shorter and the donor area heals rapidly and spontaneously unless infection is present. It is well suited to repair of large defects of the face and neck that follow severe burns or the excision of various congenital nevi (figs 364 and 365). The matching of color and texture is good though not usually as good as

it is when a full thickness graft is used. In women this may be easily remedied by the use of cosmetics (fig 366 *a* and *b*). The thick split graft has practically replaced the full thickness graft in the release of contractures of neck, axilla, elbows and hands and as linings for flaps that need two layers of skin.

One word of caution concerning the use of thick split grafts on the neck. If they are used over the thyroid cartilage, a satisfactory take cannot be expected because of movements of the larynx during swallowing. If the best possible cosmetic result is wanted it is best to use a flap of some kind for the reconstruction.



Fig 367—This patient who was seventeen years of age was severely burned by a gasoline fire one month before coming for examination. His home physician had given him excellent treatment for the third degree burn and had referred him to the Clinic for skin grafting. The extensive granulating surface which involved the entire right side of the face, chin and neck as well as some of the left cheek can be seen. The granulating tissue extended back into the scalp and back of the neck. The upper and posterior portion of the ear was missing and three fourths of the remaining portion of the ear had healed back against the scalp. Hot dressings were applied on the wound and it was painted with a solution of phemerol chloride until it was thought to be clean enough for skin grafting.

Thin split Graft—The thin split graft is easily obtained also but it should be used only for large granulating surfaces where there will be structural resistance to contracture, such as is present in the scalp, thorax or back or where contracture would do no harm. These grafts may contract as much as 60 per cent and should be used only as emergency or temporary coverings about the face, neck, axilla or joints. They are used frequently as a temporary covering for the defect left when a scalp or forehead flap has been raised.

The two most common uses of these grafts are as substitutes for congenitally absent or lost mucous membranes and as covering for large granulating surfaces which are infected. These grafts are used in making a vagina or a cavernous urethra, in correcting cicatricial deformity of the larynx, nostrils or external canals of the ear and in intra oral grafting.

When the thin split graft is used to replace mucous membranes or line a cavity, a stent is used for fixation and immobilization of the graft. Ordinarily an acrylic or vulcanite mold must be worn continually for four to six months before the contractile tendency has dis-



Fig 368—Same case as figure 367. Skin graft in place. Skin grafting was done a little more than a month after the accident. With a Padgett Hood dermatome three full drums of skin (120 square inches [305 sq cm]) were obtained for medium thickness skin grafts which were used to cover the defect. The grafts were taken from inside the left leg and the thorax and they were sutured together. The lateral silk sutures were left long enough to tie over fine mesh gauze and cotton was used for pressure. The patient had a transfusion of 1,000 c.c. of blood. Ten days later the dressing was removed and replaced with fine mesh vaselin gauze. The wound was dressed with a solution of phemerol chloride and sulfanilamide powder.

appeared. The postoperative support is of utmost importance when a thin split graft is applied to unsupported soft tissues. If a mold or obturator were not used postoperative contracture would render the procedure useless.

Medium thickness Graft—As experience with the use of split grafts is gained and better means of splinting, hemostasis and pressure are obtained, the tendency is to use the medium thickness graft rather than the thin-split graft (figs 367, 368 and 369). It is likely to be used now in the creation of a new vagina or cavernous urethra and as an intra oral graft. It would seem that eventually the thin split graft will

be used only as a temporary covering for large unclean granulating surfaces

Pinch Graft—The pinch grafts, either the thin (Reverdin) or the thicker (Davis) type have a more limited field of use than the other grafts. They occasionally may be applied to granulating surfaces in which larger grafts have been unsuccessful. They usually are used when patients have been burned severely. The general condition of these patients may be such that prolonged anesthesia for a more extensive procedure would be contraindicated. Available donor areas



Fig. 369—Same case as figures 367 and 368. Face completely healed. Later it was necessary to do a Z plastic at the lower part of the neck anteriorly due to a scarred band at this point.

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the scarring between the grafts. As time passes, these grafts are being used mainly by surgeons who perform grafting operations only occasionally and are being used less and less by the surgeon trained in plastic surgery. The results are poor.

Isograft—Isografts have been used in severely burned patients and have been considered life saving because they act as a dressing. As a permanent covering though they have been uniformly unsuccessful.

Dermal Graft—The dermal graft is used only as a buried free graft to restore the normal contour. It is particularly indicated in cases of congenital hemiatrophy of the face or in cases in which a minor amount of subcutaneous tissue has been lost as a result of some mechanical, physical or chemical agent. We prefer the dermal graft to the free fat graft because it is more likely to take without liquefaction, and postoperative shrinkage is less. The dermal graft is not indicated when large amounts of deep subcutaneous tissue have been lost. In such cases, a free-fat graft, pedicle fat graft or diced cartilage graft might be more suitable.

Pedicle Grafts—Plastic procedures utilizing neighboring tissues or free grafts or a combination of the two are adequate for a great number of defects seen by those active in surgery of repair and reconstruction. However, early in the development of this specialty, it became evident that some other method of repair was needed for extensive defects involving surface epithelium, subcutaneous tissue, epithelial lining of various cavities and frequently even deeper tissues such as bone. In such extensive defects, the restoration of function and a good cosmetic result depend on the use of a mass of tissue which is attached at some portion of its periphery or base by a pedicle through which it receives its blood supply. This mass of tissue which is called a pedunculated flap or pedicle graft may be open or tubed.

The open flap technic has been replaced to a great extent by the Filatof-Gillies tube method but it is particularly useful in those cases in which it is possible to bed the greater part of the flap into the defect after a single stage transfer. In this way, minimal subcutaneous tissue is exposed. The exposure of subcutaneous tissue, with its attendant loss of tissue fluids, excessive formation of granulation and scar tissue with contraction and generally unclean conditions which is characteristic of the open flap technic makes the open flap undesirable in the multiple stage transfers.

These factors induced Filatof and Gillies working independently, to devise the tubed flap. The greatest field of usefulness of the tubed flap is in those cases in which no massive flap is available for transfer in a single stage. It is frequently used in reparative surgery of the extremities. When the tubed flap is used large quantities of skin may be transferred safely from a distance. The tubed flap is extremely viable and adapts itself quickly to change in blood flow when attached to an intermediate host. Its flexibility allows it to be twisted and turned freely without anxiety as to its survival. Its chief disadvantage is that it may take considerable time if circumstances are such that the jump technic of multiple stage transfer cannot be used.

The pedicle graft may be transferred to the defect immediately or transfer to the new bed may be delayed in order to increase its chance of survival. The decision to delay or not to delay transfer depends on

surgical judgment at the time of operation, and this will depend on the surgeon's experience with the operation. The pallor in the flap resulting from deficient arterial supply and the cyanosis caused by venous congestion are danger signals which must not be ignored.

The immediate transfer is possible if the flap contains an artery of satisfactory size, such as the supra orbital artery in the up-and-down forehead flap or if the flap is short and has a wide pedicle. The transfer may be made in one stage when the pedicle flap is long enough to be brought to the defect by bridging across normal tissue or when the defect can be brought to the flap as in reparative surgery of the extremities.

Delayed transfer is necessary in most tube flaps or large flaps that do not contain a large artery or well established venous system.

A multiple stage transfer can be performed in two ways. First the pedicle graft is tubed and then after from one to three months one end of the tube is detached and advanced as far as it will go toward the defect and sutured into a prepared recipient area. After another period of waiting usually two weeks, the opposite end is detached and advanced toward the defect. To insure a good blood supply from the end moved first it is advisable partially to cut across the pedicle and suture it back in its position for seven to ten days before completely detaching the tube and advancing it. The second type of multiple stage transfer is called the "jump flap" method. Here the wrist or hand is used as a carrier or intermediate host so that the pedicle flap can be brought to the defect.

In many instances a pedicle graft is necessary because of the need for a lining in the restoration. A lining may be created in four ways, namely, (1) by turning in a flap of adjoining skin, (2) by inserting a free graft under one end of the pedicle graft, (3) by folding the end or side of the flap on itself or (4) by utilizing both sides of a tubed graft.

Scalp and Forehead Flaps—Hair bearing scalp flaps are used primarily to reconstruct lost portions of the scalp so that a normal hair line can be created anteriorly or laterally as reported by New and Ench.

The forehead flaps were devised for reconstruction of the nose and upper half of the face because of the excellent matching of color and texture. A quick and satisfactory reconstruction of defects of the nose and upper half of the face can be performed but these flaps produce visible scars on the forehead and leave one of the most prominent parts of the forehead that has to be covered with a free graft.

To eliminate as much of the visible scarring as possible and at the same time to produce the best cosmetic result in the reconstruction of the nose or upper half of the face, the sickle flap has been used at the Clinic³ for some time. This is a combination scalp and forehead flap



Fig 370—*a* and *b*, Same case as figures 367, 368 and 369. The loss of the greater part of the ear may be noted, and the remaining portion was buried in the skin of the mastoid region. Reconstruction of the ear was done in stages.



Fig 371—*a* and *b*, Same case as figure 370. First it was necessary to free the remaining cartilage of the ear from the mastoid region and the region above and back of the ear was grafted with a thick shaved graft. A small tube flap was made in the right cervical region about the diameter of a pencil which was carried up in stages to build the helix and posterior part of the ear. In this type of case, the lost cartilage is best replaced by obtaining some of the cartilage from another person's ear. In this case, however, it was not obtainable so tantalum wire mesh was used and so far has been satisfactory. The upper third of the ear was built up with this material.

utilizing the bay of skin just lateral to the midline and just below the hairline on the forehead. This area of skin is ideal for the reconstruction of half a nose, an ala or a tip. However, it may be used for almost any defect involving the upper half of the face.

Cervical Flaps—We have found that the small cervical tube flap is especially useful in reconstruction of ears, particularly the helix (figs 370, 371 and 372). It may be used also for some defects on the lower half of the face in men, such as losses of the upper lip. Straith has advocated its use for the reconstruction of part of the nose. For this



Fig 372—Same case as figures 370 and 371. The skin graft on the mastoid region and region above and behind the ear, as well as the graft on the posterior part of the cartilage of the ear, may be noted. The small tube flap that was used to reconstruct the helix and posterior part of the ear and lobule can be seen.

defect, the skin from behind the ear is included in the cervical flap and is utilized in the reconstruction. The cervical flap usually has sufficient length to reach from donor area to defect when used for the ear, nose or lower half of the face. Consequently, less time is required to reconstruct defects in these areas with a cervical tube flap than with tubes or flaps from other portions of the body that have to be delayed many times or need an intermediate host or carrier. On the other hand, the cervical tube flap may not offer enough tissue for the reconstruction and the scar on the neck is objectionable.

Clavicular, Thoracic and Thoraco epigastric Flaps—The chief re-

son for employing clavicular, thoracic or thoraco epigastric flaps is that they offer more tissue for the repair of certain defects in the face



Fig 373—*a* and *b* The replacement of tissue in which actinodermatitis and ulceration resulted from the roentgen treatment of tuberculous glands of the neck. A pedicle tube flap from the left thoraco epigastric region was used and it was moved to the neck by way of the back. The simpler plan of treatment of this type of condition is to excise the actinodermatitis and replace it with a fairly thick shaved graft. This makes a replacement that is quite thin and is as a rule satisfactory except that the graft nearly always breaks down in the midline of the neck over the thyroid cartilage because of movement of this part of the neck. Making and moving a pedicle flap takes longer but produces a better result. The flap however must be thinned out as it is put in place otherwise it is thicker than the normal skin in this region. In this case the patient a woman forty three years of age had marked actinodermatitis which broke down and was potentially malignant. A thoraco epigastric tube flap about 20.32 by 8.89 cm. was raised and tubed at the first operation. Later the distal end of the flap was partially cut off and then ten days later the distal end was excised completely and moved up on the back. Following this procedure the flap was attached to the left side of the neck after excision of the tissue in which actinodermatitis was present. Actinodermatitis with ulceration was found microscopically. The flap was moved to the right side of the neck and completely covered the denuded surface. After it was carried to the right side of the neck the intervening tube was smoothed out. Excision of the margins of the flap would further smooth it out and improve the result.

and neck than other grafts do. The clavicular flap should be constructed if possible, so that the skin near the sternoclavicular junction may be used in the reconstruction. The tissue in this region matches

the face well and the cosmetic result is good. In women the scarring in the clavicular area is usually undesirable. If more tissue than could be provided with the clavicular flap is needed, a thoracic or thoraco-epigastric tube may be employed. The thoracic tube provides a large roll of tissue and if devised so that skin near the clavicle is used in the reconstruction, a satisfactory matching of color will be obtained on the face. The construction of such a tube distorts the female breast. In most women then who have defects on the face or neck that require a large amount of skin or subcutaneous tissue for the reconstruction, it is best to utilize a tube raised somewhere between the axilla and the inguinal region.

The extremely long thoraco epigastric tube as described by Webster can be transferred to the defect in a single stage but it is likely to slough in the center if it is not raised in two stages. We employ a shorter subaxillary tube which has to be migrated or jumped to a defect on the face or neck (fig. 373 *a* and *b*). It is safer and it does not take much more time to accomplish the final repair than a long thoraco epigastric flap does. It is well to point out that the construction of any tube when the patient is obese may be a hazardous procedure. It is best to make the tube shorter and wider than usual and if necessary to raise or tube it in stages.

Abdominal Flaps—The short abdominal tube attached to the wrist is used when a large flap of skin and subcutaneous fat without a lining is to be transferred to a defect on the face or neck in the shortest possible time. Cosmetic results at best are none too good and may be poorer if any sloughing occurs.

Brown has pointed out recently that the large apron or doorlike flap raised from the abdomen or flank is indicated for grafting on the arm, forearm and hands when bone and tendons are exposed after burns, infections or injuries that have produced excessively fibrotic wounds with diminished blood supply so that the surface epithelium is unstable or absent and over which a free graft would not survive. If the need for tissue is not too great, a pedicle flap containing the superficial epigastric artery and vein, as advocated by Shaw, may be transferred immediately to such defects on the hand or wrist.

Flaps from Arms—Pedicule grafts utilizing skin of the arm for total or partial rhinoplasty should be used only when no skin is available on the forehead. Skin obtained in this manner poorly matches the rest of the face and sloughing of important parts of the flap is a strong possibility.

Flaps from Legs—Tubed or open leg flaps are indicated for the opposite thigh, leg, or foot and ankle for the same reason that the apron or doorlike abdominal flaps are indicated for the arm, forearm and hand. These reasons have been outlined in the discussion of abdominal flaps.

On the heel or sole of the foot the additional factor of weight bearing must be considered. Free grafts often fail to correct defects in these situations. It is frequently necessary to use a pedicle graft to furnish a good pad of subcutaneous fat.

Flaps from the Back—Pedicle flaps raised from the back are indicated rarely. The skin is coarse and thick and tends to be yellow around the face or neck. Sometimes in severely burned patients, the abdomen or thorax may not have suitable skin for grafting purposes. A flap from the back may be necessary then but its use as an optional procedure is not recommended.

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SOME TECHNICAL ASPECTS OF SURGERY OF THE THYROID GLAND

JOHN DEJ PEMBERTON AND B MARDEN BLACK

THE operation of subtotal thyroidectomy, as carried out at the Mayo Clinic, has remained substantially unchanged over the past twenty five to thirty years. The basic principles of the operation as listed by one of us (Pemberton⁵) more than twenty years ago are as follows: (1) the removal of sufficient thyroid tissue, (2) the preservation of thyroid tissue to maintain adequate function, (3) the control of bleeding (hemostasis) and (4) the avoidance of sepsis and injury to neighboring structures.

While these principles are probably generally acceptable, there is some controversy as to the amount of thyroid tissue which should be preserved, particularly in operations for exophthalmic goiter, and there is also some difference of opinion as to how best to prevent damage to surrounding structures notably to the recurrent nerves.

THE AMOUNT OF THYROID TISSUE TO BE REMOVED

In the case of the disease, exophthalmic goiter, experience has demonstrated that remissions of the disease can be produced by the removal of 65 to 85 per cent of the thyroid gland, that the basal metabolic rate will fall to normal levels within about two weeks following the operation and that in only a small proportion of the cases will recurrence of the disease develop. In short, while it would seem disadvantageous to preserve diseased tissue in either side equal to a sixth to a quarter of a normal sized lobe, we believe that, by such an operation there will be complete remission, although in some cases for a variable period. In exophthalmic goiter, on this basis, is the removal of the forces which caused the original disease. Its development, almost invariably, is associated with gross hypertrophy of the thyroid tissue which was left behind at the original operation. In view of the marked regenerative capacity of thyroid tissue, it seems improbable to us that recurrences could be prevented by more radical thyroidectomy, provided that sufficient thyroid tissue were left behind to supply the normal needs of the patient. The objections to extremely radical subtotal thyroidectomy are that there is greater chance of injuring the recurrent nerves, more chance of removing parathyroids, and myxedema is more likely to develop than with more conservative resections. It need not be emphasized that the resection must be sufficiently radical to induce a remission of the disease, and it follows that persistent

exophthalmic goiter, in contradistinction to recurrent exophthalmic goiter, is due to inadequate resection and the consequent preservation of too much thyroid tissue

Since the principal objective of the operation for adenomatous goiter is the removal of all the encapsulated and partially encapsulated nodules, it follows that the amount of tissue that is preserved varies greatly, depending in large measure on the amount of thyroid gland free of nodules. Thus, if the nodule or nodules are confined to one lobe, the operation may be limited to the resection of the involved lobe unless it seems advisable to resect the second lobe for cosmetic reasons whereas in cases of multiple adenomatous goiter in which both lobes are involved, the resection of all the nodules may result in the removal of all but a small remnant usually consisting of the posteromedial portion of each lobe. We should like to emphasize again that both lobes of the thyroid should be elevated and exposed at operation in virtually all cases of adenomatous goiter in order to determine that substernal and retrotracheal projections, which were not evident clinically, are not present. Such projections are overlooked frequently and may necessitate a second operation.

AVOIDANCE OF INJURY TO THE RECURRENT NERVES

Injury to one recurrent nerve, with consequent paralysis of the corresponding vocal cord, is, as a rule, not followed by permanent serious consequences. The patient usually has some transient hoarseness but the airway usually remains adequate and unless the voice is used professionally or for long periods the paralysis commonly does not produce permanent noticeable change in the speaking voice. Injury to the recurrent nerves on both sides, with resulting bilateral paralysis in marked contrast is a catastrophe which may cost the patient's life and, at best, will be followed by extremely serious symptoms. Obstructive dyspnea develops, either immediately or over a period of three to six months. In the former case, tracheotomy is usually necessary as an emergency procedure, while in the latter case, the impairment of the airway becomes so marked that either the patient's activities must be most limited, or tracheotomy must be performed. Pneumonia is to be expected following bilateral injuries to the recurrent nerves because of impaired cough, anoxemia and the aspiration which may result from defective swallowing. While a satisfactory operative procedure is available to restore the airway (King³), the results as to both airway and voice are not perfect.

The traditional measures to prevent bilateral injuries to the recurrent nerves are twofold. 1 The regions traversed by the nerves are avoided by preserving the medial and posteromedial segments of the lobes. 2 The resection on one side is completed and the integrity of the nerve on this side is verified before the dissection of the opposite

side is started. To test for the integrity of the nerve the patient must be awakened following resection of the first lobe and thus implies that the anesthesia must be sufficiently light to permit this. The combination of local field block with procaine hydrochloride and light general anesthesia with nitrous oxide and oxygen has been found satisfactory. Should the nerve be injured the resulting paralysis of the vocal cord can be detected by changes in the voice and the character of the cough. Since the tests are applied after each lobe has been resected it is known with certainty whether the injury if present affects the right or the left recurrent nerve and the injured nerve may be dissected out without fear of injuring the intact nerve. If the nerve has been injured by tension pressure or its inclusion in a tie function can be expected to return if the tie is removed. If the tie is allowed to remain around the nerve the injury will be permanent. If the nerve is injured during the resection of the first lobe the operation may be terminated after the complete dissection of the nerve as it traverses the operative field and after making the necessary repair. Resection of the second lobe is postponed for several months to allow time for the nerve to regain its function.

Lahey⁴ in 1938 reported that the number of injuries to the recurrent nerves had been reduced materially by the adoption of a different method to protect the nerves. He suggested that by exposing the nerves near the inferior pole and by palpating the inferior horn of the thyroid cartilage just posteriorly to which the nerves enter the larynx the course of the nerves could be estimated with some exactness. Although exposure of the nerves near the inferior pole of the thyroid does not present any particular difficulties we have not adopted the method as a routine procedure but prefer to avoid the entire region as previously outlined.

It is probably redundant to point out that a thorough knowledge of the position of the recurrent nerves and their possible variations will go far to prevent their injury and with this in mind a brief review of the anatomic relations of these nerves in the neck follows.

The recurrent nerves differ in their relationships in the two sides of the neck. The right nerve after passing around the subclavian artery courses proximally and medially well lateral to the tracheo esophageal groove. It does not reach the side of the trachea until it approaches the adherent zone and at the level of the clavicle may be as much as 1 cm. lateral to the trachea. The left nerve passes medially as it arches around the aorta and courses upward in the neck deep within the tracheo esophageal groove. Either nerve may pass posteriorly anteriorly or between the branches of the inferior thyroid artery and the frequency with which the nerve follows each course differs on the two sides.

On the right side the nerve is likely to be more anterior than on

the left a point of considerable surgical importance Berlin¹ found, in a series of seventy dissections on cadavers of 140 inferior laryngeal nerves that the right nerve coursed posteriorly to the inferior thyroid artery in 44 per cent of the cases anteriorly to the artery in 40 per cent and between the branches in 16 per cent The left nerve passed posteriorly to the artery in 63 per cent of the cases anteriorly to the artery in 24 per cent and between the terminal branches in 13 per cent As the nerve continues proximally it may pass posteriorly to the adherent zone through the adherent zone or may arch up into the thyroid tissue At this level again the nerve tends to be more anterior on the right than on the left side Berlin found that on the right side the nerve arched up to pass through thyroid tissue in 13 per cent of cases coursed through the adherent zone in 27 per cent of cases and passed proximally in the tracheo esophageal groove in 60 per cent On the left side the nerve arched up through thyroid tissue in 7 per cent passed through the adherent zone in 23 per cent and ran in the tracheo esophageal groove in 70 per cent of cases The nerve may divide before it enters the larynx and the two divisions may pursue somewhat different courses proximally in relation to the adherent zone and artery Rarely the nerve on the right side may originate from the vagus in the neck and pass medially to reach the adherent zone⁷

When the lobe of the thyroid is elevated and rotated the recurrent nerve is dislocated from its deep position in those cases in which it courses anteriorly to or between the branches of the inferior thyroid artery (right 56 per cent of cases left 37 per cent of cases) In the remaining cases the nerve does not follow the lobe and hence remains largely out of harm's way While the nerve may be traumatized at any point in its course through the operative field it is more exposed to injury in two places than elsewhere 1 Distal to the adherent zone and the point where the inferior thyroid artery reaches the lobe the lobe is not attached to the trachea Excessive mobilization of this part of the lobe may carry the nerve anteriorly into the plane where hemostats are applied in those cases in which the nerve courses anteriorly to or between the branches of the inferior thyroid artery (right 56 per cent of cases left 37 per cent of cases) 2 In those cases in which the nerve passes through the adherent zone or actually through thyroid tissue (right 40 per cent of cases left 30 per cent of cases) it may be caught as clamps are applied to the medial side of the lobe This portion of the lobe is abundantly supplied by arterial branches from the inferior thyroid artery which course from behind forward and attempts to catch an escaped bleeding vessel in the region by deeper clamping may eventuate in injury to the nerve To stop such bleeding it is wiser by far to ligate the main trunk of the inferior thyroid artery before it has reached the lobe

In spite of the more protected position of the left nerve it is injured probably more frequently than the right, partly because of the fact that a right handed surgeon stands on the patient's right and has a more limited view of the posteromedial surfaces of the left lobe than of the right and partly because of overmobilization and rotation of the left lobe. This is made possible by the loss of the outrigger effect of the right lobe, which is commonly resected first, limiting rotation of the trachea.

OPERATIVE TECHNIC

The operation can be best described in connection with the illustrations. Local field block anesthesia using 0.5 per cent solution of procaine hydrochloride, combined with light general anesthesia using nitrous oxide and oxygen is employed. The general anesthesia usually

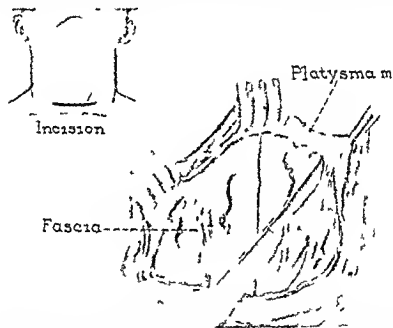


Fig. 374.—The inset illustrates the position, length and curve of the incision. In the main part of the figure the upper flap is being raised in a cleavage plane just superficial to the first layer of the deep cervical fascia.

is required only during resection of the first lobe. Preoperative medication is limited to $1\frac{1}{2}$ grains (0.1 gm.) of pentobarbital sodium given orally about one hour prior to operation and $\frac{1}{4}$ grain (0.016 gm.) of morphine sulfate given hypodermically just before the patient comes to the operating room. Deep sedation is avoided preoperatively because of the necessity of securing the patient's cooperation to test for the integrity of the recurrent nerves.

The incision (fig. 374) is made approximately 2 cm. above the sternal ends of the clavicles, the actual position depending somewhat on the length of the neck and the relative position of the goiter. With the neck moderately extended, the incision should be almost horizontal because of the tenting of the skin in the midline by the chin. When the chin is lowered the incision will assume a gentle curve with the convexity downward. The position and shape of the incision may be traced on the skin, using a string of beads as a guide. If the incision overlies the sternoclavicular articulations, the scar will tend to widen. If the incision is too high it cannot be concealed by a collar or beads. Incisions which are too curved leave an unsightly scar and curved incisions with the convexity upward are entirely unsatisfactory. The length of the incision will vary somewhat with the size of the neck and the size of the goiter but, generally speaking, it need not be longer than the distance from the top of the thyroid cartilage to the sternum.

The incision (fig. 374) is deepened through the platysma muscle and the upper flap is raised by combined blunt and sharp dissection. The proper cleavage plane lies just anterior to the first layer of the deep cervical fascia and is readily found if traction is made anteriorly and upward by an assistant. The upper flap is raised to just above the level of the notch of the thyroid cartilage. The lower flap is raised only sufficiently to afford engagement of a self-retaining retractor of the Beckman type. Deeper flaps, which include the anterior layer of the deep cervical fascia, may be raised but this necessitates division of the anterior jugular system of veins and the dissection involves more loss of blood than with the more superficial flaps. After the flaps have been raised, skin towels are applied to the edges of the incision and the self-retaining retractor is inserted. General anesthesia is induced.

The deep cervical fascia is incised in the midline from the notch of the thyroid cartilage to the sternum (fig. 375). Distally the deep cervical fascia divides into two lamina which attach to the anterior and posterior surfaces of the sternum, respectively, and enclose a space through which horizontal veins course between the anterior jugular veins of the two sides. If it is necessary to cut these veins the ends should be secured by stick ties. Greater exposure can be obtained if the space between the sternohyoid and the sternothyroid muscles on each side is opened up, usually by a sweep of the finger. The thyroid gland is grasped by forceps and elevation and exposure of the lobe is started (figs. 376 and 377). It has been our experience that forceps of the Ochsner type are more satisfactory than the many special grasping forceps which have been devised. Particularly with friable thyroids, the capsule is the strongest part of the lobe and forceps of the Ochsner type can secure a broad bite of capsule when

one blade is thrust well along the lobe just beneath the capsule. Multiple forceps may be so inserted and a secure hold on the lobe may be obtained without fragmenting it.

The lobe is rotated medially as it is being elevated while counter traction is being made on the prethyroid muscles. The proper cleavage plane is readily found in primary cases. We do not as a rule divide the sternohyoid muscles although the muscles may be divided without fear of producing any deformity in the contour of the neck. If the muscles are divided the division should be made between

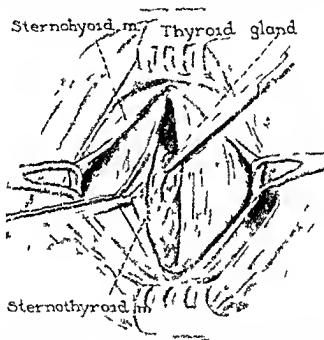


Fig. 375.—The deep fascia has been incised in the midline from the level of the laryngeal prominence to the sternum. The space between the sternohyoid and the sternothyroid muscles on either side has been opened up.

clamps in the upper third of the muscle so as to avoid injury to their nerve supply and the cut ends of the muscles should be resutured at the completion of the operation. The cut ends of the anterior jugular veins should be carefully secured by the stick ties if the muscle is divided.

The middle thyroid vein or not infrequently multiple branches of it are encountered toward the lateral and posterior margin of the lobe. The vein is carefully isolated and divided between clamps (Fig. 376). The clamps are replaced promptly by ties. Should the lateral thyroid vein be torn or avulsed from the jugular it is usually difficult

to secure it at this stage of the operation because of limited exposure. The insertion of a gauze pack will control the bleeding and definitive control of the bleeding may be postponed until the lobe has been resected and more ample exposure secured. The lobe is readily exposed completely and elevated out of its bed following division of the vein.

The superior pole is exposed by downward traction on the lobe (fig. 377) and the superior thyroid vessels are doubly clamped just above the pole. The exposure should be sufficient to insure that no thyroid tissue is left above the clamps because of the possibility of the tissue subsequently undergoing hypertrophy and producing a

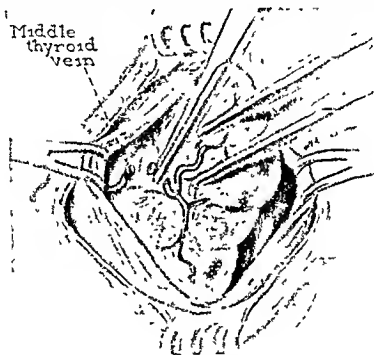


Fig 376—The thyroid gland is being mobilized, the Ochsner hemostat being used to grasp the capsule. The middle thyroid vein has been ligated.

rather unsightly lump beneath the skin of the neck. Adenomatous tissue occasionally projects well above the junction of the superior thyroid vessels and the lobe and when such tissue lies posterior to the vessels it is easily overlooked. Such tissue must be well mobilized and adequately resected. Downward traction on the lobe with the index finger of the surgeon grasping the lobe from behind will aid materially. The suspensory ligament and isthmus are successively clamped and divided. Several bites may be necessary to divide the isthmus satisfactorily. The isthmus should be divided completely and no thyroid tissue is left anterior to the trachea across the midline.

The actual resection of the lobe is started from the tracheal or medial side of the lobe and continued laterally (fig 378). The proper

saved than parenchyma and the resection is never carried posteriorly into the adherent zone. The resection of the lobe is started by the application of a row of clamps to the medial side of the lobe in a

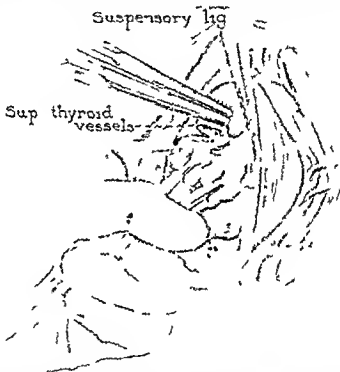


Fig 377—The superior pole of the thyroid gland has been exposed and the superior thyroid vessels have been doubly clamped. The suspensory ligament has been clamped.

frontal plane passing through the anterior wall of the trachea. This line of resection is continued for about 0.5 cm to clear the bulge of the wall of the trachea. This first row of clamps serves two important functions other than that of hemostasis: (1) they delineate the anterior margin of the adherent zone and (2) the tissue that they grasp will act subsequently to afford anchorage for sutures applied to control oozing, by approximating the posterolateral capsule to the trachea. The resection is continued posterolaterally, the gland being sectioned after clamping until the posterolateral portion of the capsule

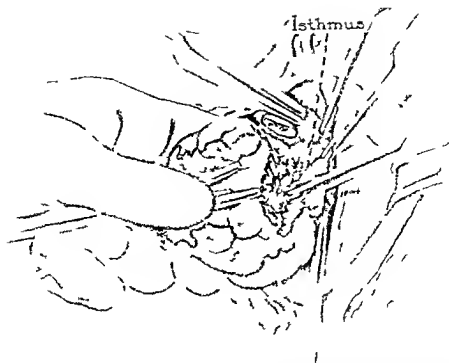


Fig 378—The actual resection of the lobe has been started from the medial or tracheal side. The surgeon's left hand keeps the lobe elevated and controls bleeding.

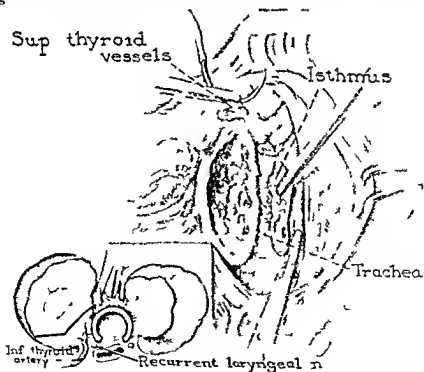


Fig 379—The inset shows the proper line of resection. In the main part of the figure the lobe has been resected and the superior thyroid vessels are being ligated.

is approached. During the resection the lobe is elevated by the surgeon's left index finger so that the clamps need not be applied farther posteriorly than a frontal plane passing through the anterior wall of the trachea. Oozing of blood is also controlled by pressure of the finger from below. Three or four clamps are applied to the posterolateral portion of the capsule about 0.5 to 1.5 cm. above the line of the resection, thus saving more capsule than parenchyma, and the resection is completed (fig. 379). All the forceps attached to the remnant of the lobe are replaced by the ties, stick ties being used when necessary.

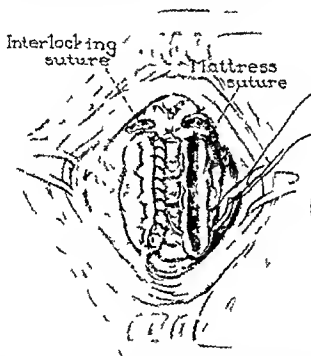


Fig. 380—Resection has been completed on both sides and the posteromedial portion of the capsule is being sutured to the tissue which was preserved along side the trachea.

It is apparent that the resected region will be wedge shaped leaving thyroid tissue preserved above the recurrent nerve medially and above both nerve and parathyroid glands laterally. The medial and lateral surfaces of the remnant are approximated and the remnant is sutured to the trachea employing the tissue which was saved originally along the anterior border of the adherent zone (fig. 380). The needle should never be introduced more posteriorly than the frontal plane passing through the anterior wall of the trachea because of the

possibility of picking up the recurrent nerve. In practice, we usually leave the second tie on the superior pole long and employ the loop end as the suture. The suture is carried distally along the lobe as a continuous mattress suture, locked around the inferior pole and returned as a locking suture, the needle being inserted just posteriorly to the previous sutures. In our opinion, this suture has considerable importance. It not only controls oozing from the remnant but fixes the remnant to the trachea so that it will not be avulsed by swallowing movements.

General anesthesia is discontinued and the patient is awakened before any dissection is started on the second lobe. If the nerve has been injured, with resulting paralysis of the corresponding vocal cord, there is usually a definite change of the patient's voice. However, change of voice may be confusing because of lack of co-operation on the patient's part, mucus, removal of artificial dentures or like causes. More definite is the impairment of the patient's cough which follows recent injury of the recurrent nerve. The paralyzed cord cannot be tensely adducted and hence intrathoracic pressure cannot be voluntarily increased to produce an explosive cough. If the patient can cough explosively, it is proof that a recent paralysis of the vocal cord is not present. The test is invalid for old injuries of the recurrent nerve since the paralyzed cord becomes fixed in the midline and loses its flaccidity.

If the nerve has been injured, it is dissected out in its course through the operative field, for the purpose of freeing it from ties. The operation is usually terminated with dissection of the nerve and the removal of the second lobe is postponed for three months to permit return of function to the nerve.

If the nerve has not been injured, the second lobe is resected in the same manner as the first side. General anesthesia is usually not necessary during the resection of the second lobe. Care should be exercised that the lateral wall of the trachea on the second side is not inadvertently exposed, and that the resection on the second side is not too radical. The pyramidal lobe, if present, should be removed completely. This is done conveniently while waiting for the patient to awaken after resection of the first lobe.

If after the resection of both lobes and after all bleeding has been controlled by ties or suturing there exists any doubt in the mind of the surgeon regarding the adequacy of the hemostasis—either because of the vascularity of the gland or because of the need of mass-sutures to control bleeding—the one or both inferior thyroid arteries are ligated at a point proximal to their entrance into the gland (fig. 381). Experience with many thousands of cases has proved that this procedure has greatly reduced the incidence of postoperative bleeding and that its employment is not fraught with danger of producing inadequate blood

supply to the parathyroid glands or to the remnant of the thyroid, provided the operation is carried out in the manner described previously, whereby the preserved remnant of the thyroid gland is not detached from the lateral wall of the trachea so that its collateral circulation supplied by the vessels from the trachea is not destroyed. In our practice, the inferior thyroid artery is ligated on one or both sides in possibly 90 per cent of cases as an added precaution against secondary hemorrhage. The exact position of the artery can be determined usually from inspection and palpation. It rises to various heights in the neck, passes behind the carotid artery and runs downward and medially to reach the posteromedial border of the lobe near the junction of the inferior and middle thirds. Its exposure will be facilitated

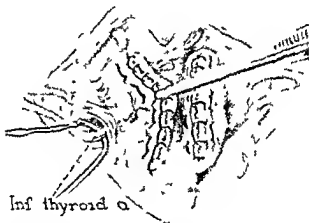


Fig 381—The inferior thyroid artery has been ligated well laterally

if medial traction is made on the remnant and if the carotid artery is displaced laterally. The ligation is more easily done after the lobe has been resected than before but frequently it is possible to ligate the artery before the resection is started. In the latter case there will be far less oozing during the resection than if ligation is deferred until after resection.

The closure of the incision needs little comment. We employ drainage routinely, leaving a Penrose drain extending to each remnant, and bringing both drains out together, near one end of the incision (fig 382). The drains are brought out between the sternohyoid and sternocleidomastoid muscles and not through the midline, in an effort to avoid adhesions between the skin and the trachea. We see no very valid reason why drainage should not be used following thyroidectomy. If the drains are removed within forty-eight hours and if

they are not brought out through stab wounds through the skin, they do not impair the scar in any way. The use of drains not only permits the escape of any serum which may collect in the operative field but also permits early and easy diagnosis of postoperative bleeding, usually before enough blood has collected to produce serious symptoms due to pressure.

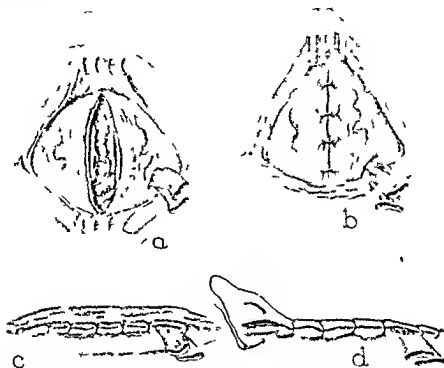


Fig 382—Steps in the closure of the incision. The fascial layer has been closed in the midline and the drains have been brought out through the incision well laterally.

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COMPLICATIONS AND TREATMENT OF BRONCHIAL ADENOMAS

O THURON CLACFET AND JOHN H. PAYNE

BRONCHIAL adenoma is one of the most interesting of pulmonary tumors. At the present time there is still some controversy about these tumors, particularly with regard to their origin, malignancy or benignancy and treatment. It is generally agreed that bronchial adenomas constitute a definite pathologic and clinical entity, however, and that it is not the tumors but the complications that result from them that present the greatest hazard to the patient.

GENERAL CONSIDERATIONS

Several hypotheses about the origin of bronchial adenomas have been made, but Graham and Womack have presented the most likely explanation. They were of the opinion that these tumors occur when the bronchial buds fail to develop into the orderly arrangement of tissues regarded as normal. According to their hypothesis when the mesodermal elements predominate, chondromas, osteomas, lipomas or fibromas result and when the entodermal elements are dominant, bronchial adenomas occur. Bronchial adenomas occur only in the main stem bronchi. On bronchoscopic examination they usually can be visualized and a specimen of the lesion can be taken for biopsy.

Microscopic Appearance.—The microscopic appearance of these tumors is characterized by closely packed, cuboid and columnar cells with small darkly staining round or oval nuclei in which mitosis is rarely seen. These cells are arranged in two or more layers between which spaces of varying size are found. The stroma is vascular and often edematous.

Illustration of a bronchial adenoma.

Fig. 1

bronchial portion of the tumor is much larger than that portion lying within the bronchus. It is impossible for the bronchoscopist to determine the size of the tumor. Ulceration of the tumor is rare.

Sex and Age Incidence.—It is interesting that about 60 to 80 per cent of bronchial adenomas occur in women whereas about 50 per cent of bronchogenic carcinomas occur in men, and that bronchial adenomas usually develop in patients less than forty years of age whereas carcinoma of the lung usually occurs in patients more than forty years of age.

Symptoms.—The clinical history varies considerably but, since these are slowly growing lesions, they often develop gradually over a period of years. Cough and hemoptysis are frequent symptoms and severe hemorrhages due to the vascularity of these tumors occur occasionally. Cough productive of considerable sputum is common and often a history of recurrent episodes of pneumonia and pleurisy is given.

The symptoms resulting from bronchial adenoma are due largely to the bronchial obstruction caused by the tumor. If little obstruction is present, symptoms are minimal. As the tumor enlarges bronchial obstruction with atelectasis of the lung distal to the tumor and pulmo-



Fig. 383—The thorax showing no abnormality.

nary suppuration with retention of infected secretion in the bronchi develops. The severity of these conditions may increase and actual necrosis of the lung and empyema may result. Even if the obstructing tumor is removed by bronchoscopic means often a permanent residue of pulmonary damage and bronchiectasis remains.

Roentgenologic Examination.—The usual roentgenographic evidence of bronchial adenoma is collapse of the entire lung if the main bronchus is obstructed, or of a lobe if the tumor is distal to the main bronchus. If obstruction of the bronchus is not complete, bronchiectasis and pneumonitis may be suggested. Bronchographic studies of the bronchial tree may show the tumor as a smooth filling defect in

the bronchial wall. The tumor can sometimes be demonstrated by tomographic studies.

Rarely an adenoma of the bronchus may be present without producing any roentgenologic evidence of its presence. In one case the roentgenogram of the thorax showed no abnormalities (fig. 383) but, because the patient complained of cough and hemoptysis, bronchoscopic examination was made. The lesion was found and at operation an adenoma projecting into the bronchus was removed (fig. 384). Hence, if a patient has symptoms referable to the tracheobronchial tree, bronchoscopy is indicated even if the roentgenogram is normal.

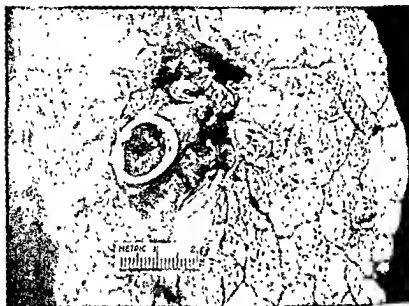


Fig 384—Bronchial adenoma projecting into the lumen of the bronchus.

Treatment.—There is some controversy regarding the treatment of bronchial adenomas. Since the tumors are relatively benign, slowly growing lesions which rarely metastasize, removal of these lesions through the bronchoscope has been advocated by some as the treatment of choice rather than pulmonary resection. Undoubtedly in some cases this method of treatment is preferable. In general, however bronchoscopic removal of bronchial adenomas should be performed only when the general condition of the patient will not permit pulmonary resection for the following reasons: 1. It is impossible to remove the entire growth by means of the bronchoscope because in many cases most of the tumor lies outside the bronchus (note case 4) 2 Repeated bronchoscopy at frequent intervals for the rest of the patient's life will be necessary for the tumor may recur (note case 3)

3 Bronchial adenomas are highly vascular tumors and severe hemorrhage may be encountered at the time of bronchoscopic removal. 4 Even though these tumors grow slowly and are relatively benign, cases of metastasis have been reported. 5 The risk of surgical resection is not great, usually less than 5 per cent. 6 Extensive pulmonary damage, particularly bronchiectasis and severe pulmonary suppurative disease distal to the tumor, cannot be treated successfully except by resection (note especially cases 1 and 2).

Although pulmonary resection is the treatment of choice in most cases of bronchial adenoma, bronchoscopy plays an invaluable role in the diagnosis of the lesion and in determining the exact location of the tumor so that the extent of the operation can be planned beforehand. Furthermore, it is useful in preparing the patient for operation. Removal of the intrabronchial portion of the tumor through the bronchoscope will relieve the atelectasis and then the acute pulmonary suppuration can subside preoperatively. Relief of bronchial obstruction by means of the bronchoscope too will permit drainage of retained infected pulmonary secretions and thus allow an improvement in the patient's general condition. Thus operation can be performed under the most favorable conditions possible.

Anemia should be treated with administration of iron and transfusions if necessary in the preoperative period. Many patients are undernourished and have vitamin deficiencies which require attention. We have found that penicillin administered both by nebulization and intramuscularly has been beneficial.

Operation is performed after the patient has been restored to the best condition possible. Lobectomy is performed whenever possible, but in many instances the location of the tumor makes pneumonectomy necessary. Thus far in the cases which we have encountered it has been possible to carry out hilar dissection with individual ligation of the vessels and closure of the bronchus in every case in which operation has been performed and it has not been necessary to resort to use of a tourniquet. As a result few postoperative complications have occurred. Pulmonary suppuration and severe inflammatory reactions have made many of the operations technically difficult and shocking. If anesthesia is induced correctly and blood transfusion during the operation is adequate to replace the blood lost, the patient can be maintained in good condition throughout a long, technically difficult operation.

REPORT OF CASES

The following cases illustrate some of the complications that can result from bronchial adenoma.

CASE 1—When the patient, a woman twenty-nine years of age, entered the Clinic she was acutely ill. Three years prior to admission a dry cough had de-

veloped which gradually had increased in severity. In the year prior to admission she had had episodes of fever and chills and her cough was productive of foul pus.

On admission, the patient's temperature was 103° F, pulse rate, 130 beats per minute and respiratory rate 32. She lost 30 pounds (13.6 kg) in the previous year. The level of hemoglobin was 7.3 gm per 100 cc, erythrocytes numbered 2,660,000 per cubic millimeter of blood, leukocytes 31,600 and sedimentation rate was 126 mm in one hour (Westergren method). Cough was productive of two to three cupfuls (about 240 to 360 cc) of foul sputum daily. Examination of the sputum revealed no tubercle bacilli. Roentgenograms of the thorax revealed atelectasis of the left lung, fluid in the left pleural space and multiple fluid levels in the lung indicating abscesses (fig 385, a and b). Bronchoscopic examination revealed an adenoma of the left main bronchus at the level of the upper lobe. Enough of the tumor was removed to permit better drainage of the retained secretion.



Fig 385 (Case 1)—Fluid in thorax. *a*, On admission extensive suppurative process in the left lung with multiple fluid levels. *b*, After operation fluid in the left pleural space.

Pneumonectomy was advised and the patient agreed to the operation and was hospitalized. Preoperatively she was given a total of four transfusions of 500 cc of blood and 150,000 Oxford units of penicillin was administered intramuscularly daily. Nine days after admission to the hospital pneumonectomy was performed. The operation, which was carried out extrapleurally, was difficult. The lung was so infected that it had ruptured into the pleural space and extensive contamination had occurred. Pneumonectomy was carried out with individual ligations of the hilar structures and the bronchus was closed with a single row of interrupted silk sutures. The pleural space was closed without drainage. During the operation 3,000 cc of blood was given.

On bronchoscopy at the close of the operation a moderate amount of mucus and pus was removed from the bronchus on the right. Also a fragment of tissue about 2 by 0.5 cm was removed from the right bronchus. This proved to be a portion of the adenoma which had broken off from the main growth and had been aspirated into the right main bronchus.

On pathologic examination of the removed lung an adenoma 3.5 by 2.5 by 1

cm was found in the left main bronchus. There was extensive bronchiectasis with almost complete destruction of the entire lung (fig 386).

The postoperative course was completely uneventful and empyema did not develop. The patient was dismissed on the twenty-first day after operation.

Comment.—This case illustrates that adenoma of the bronchus may cause extensive damage to the lung as well as the magnitude of the problem presented in some of these cases. It is hard to imagine a poorer candidate for a serious operation than a patient who has toxemia and anemia and is malnourished. However, in this case the administration of adequate blood transfusions, penicillin and proper



Fig 386 (Case 1) —Almost complete destruction of the entire lung may be noted

anesthesia improved the condition of the patient so that operation could be performed successfully. The value of postoperative bronchoscopy for patients who have undergone pulmonary resection is illustrated particularly in this case, for not only was purulent material removed from the bronchi of the remaining lung but a portion of the tumor which had been aspirated into this lung was removed. Had this not been done serious complications in the remaining lung could have developed postoperatively.

CASE 2—The patient, a man twenty-nine years of age, was admitted to the Clinic. He had had respiratory symptoms for four years. He gave a history of four episodes of pneumonia, cough, fever, chills and expectoration of purulent material. Between episodes which lasted three or four weeks, he had a productive cough. Several months previous to admission episodes of chills, fever and



Fig 387 (Case 2) —a and b Collapse of the left lung

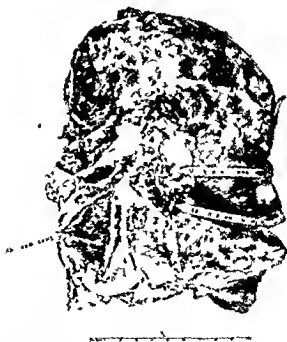


Fig 388 (Case 2) —Specimen removed at operation showing tumor and extensive destruction of the lung distal to the obstruction

night sweats became more frequent and pain developed in the left portion of the thorax and dyspnea occurred when he walked Hemoptysis had occurred once

On admission the patient's temperature was 103° F pulse rate was 110 and respiratory rate 22 The erythrocyte count was 4 260 000 per cubic millimeter of blood level of hemoglobin 13.5 gm per 100 cc and sedimentation rate 102 mm in one hour (Westergren method) Examination of sputum revealed no tubercle bacilli Roentgenologic examination showed complete collapse of the left lung (fig 387 a and b) Bronchoscopy revealed that a polypoid rounded tumor mass was present in the left main bronchus and arose from the posterolateral wall just below the upper lobe bronchus Biopsy revealed this to be an adenoma of the bronchus Attempts to remove enough of the tumor to permit drainage of the infected secretion distal to the growth were unsuccessful because of the bleeding encountered Therefore pneumonectomy was advised and was performed six days after admission

The operation was extremely difficult The lung was densely adherent to the thoracic wall so that most of the dissection was carried out extrapleurally In spite of this gross contamination of the operative field occurred and the fable infected lung was ruptured in one place Hilar dissection and individual ligation of the vessels were carried out Postoperative bronchoscopy was performed and a large amount of purulent material was aspirated from the right lung

Pathologic examination of the removed lung revealed an adenoma of the bronchus 3 by 2.5 by 1 cm and diffuse purulent pneumonitis multiple abscesses and bronchiectasis (fig 388)

The patient's postoperative course was entirely satisfactory Empyema did not develop He was dismissed from the hospital on the fourteenth postoperative day

Comment—This case also illustrates the extensive damage that can result from adenoma of the bronchus The lung was almost completely destroyed In this case it had been impossible to remove a sufficient amount of the tumor by bronchoscopic means to permit good drainage therefore the operation was performed under unfortunate circumstances During manipulation a considerable quantity of pus from the infected bronchus flooded the tracheobronchial tree before it was possible to carry the dissection down to the bronchus on the left and occlude it However, the anesthesia was good and aspiration of the tracheobronchial tree was carried out during the course of the operation These factors made it possible to perform the operation

CASE 3—The patient a man thirty five years of age first registered at the Clinic in 1935 and was seen for examination several times after that In 1935 he gave a history of cough expectoration and episodes of chills and fever of three years duration His condition had been diagnosed elsewhere as tuberculosis Tubercle bacilli had never been demonstrated He had had occasional hemoptysis On roentgenographic studies of the thorax at the Clinic complete collapse of the lower lobe of the right lung was found Sedimentation rate was 76 mm Bronchoscopy revealed an adenoma of the right lower lobe bronchus This was removed through the bronchoscope and deep roentgen therapy was given The patient improved the cough hemoptysis and fever disappeared and he gained weight He returned in 1937 and at that time no evidence of recurrence of the tumor was found In 1940 he began to cough and raise purulent sputum and bronchoscopy re

vealed a recurrence of the adenoma. Surgical resection of the lobe was advised but was refused by the patient. The intrabronchial portion of the tumor was removed through the bronchoscope again and radon seeds were inserted on two occasions.

The patient was well until 1945 when cough and hemoptysis again developed. On bronchoscopy an obstruction of the right stem bronchus and bronchiectasis in the middle and lower lobes were found.

Operation was again advised and was performed on November 29, 1945. The lower and middle lobes of the right lung were removed. The operation was difficult but hilar dissection and individual ligation were carried out. Pathologic examination of the specimen removed at operation revealed the growth to be an adenoma originating in the right bronchus which measured 3 by 2.5 by 2 cm. It was situated almost entirely outside of the bronchus. Marked bronchiectasis, pneumonia and fibrosis were present. The postoperative course was entirely satisfactory and the patient was dismissed from the hospital on the fourteenth postoperative day.

Comment—This case illustrates the futility of bronchoscopic treatment of adenomas. In this case as in most cases, a large portion of the adenoma was extrabronchial and could not be removed by bronchoscopic means. Eventually surgical procedures became necessary because of serious complications. These made the operation more difficult and dangerous than it would have been earlier.

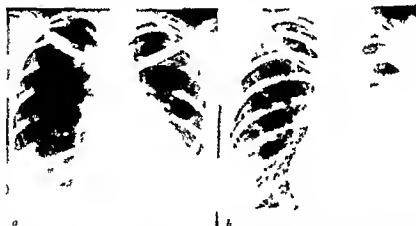


Fig. 389 (Case 4)—a Atelectasis of the left lower lobe b After pneumonectomy

CASE 4—A woman thirty one years of age registered at the Clinic on June 1, 1944. She gave a history of recurrent bouts of pneumonia of about fourteen years duration. In January 1944 bronchoscopic examination elsewhere had revealed a lesion in the left bronchus. A roentgenogram of the thorax made after admission revealed atelectasis of the left lower lobe (fig. 389 a and b). Results of studies of the blood were within normal limits. Examination of the sputum revealed no tubercle bacilli. Bronchoscopy revealed a polypoid tumor of the left lower lobe bronchus just below the orifice of the upper lobe bronchus which completely occluded the lower lobe bronchus. Pathologic examination proved this to be an adenoma of the bronchus.

Operation was advised and was performed on June 12, 1944. We had hoped that it would be possible to perform lower lobectomy, however, it was impossible to remove the lesion completely without performing pneumonectomy. Pneumonectomy was performed and the hilar structures were ligated individually. The postoperative course was entirely satisfactory and the patient was dismissed from



Fig 390 (Case 4) —Huge adenoma of the bronchus measuring 8 by 5 by 4.5 cm with complete collapse of the lung distal to the tumor

the Clinic on the eighteenth day after operation. On pathologic examination the tumor was found to be an adenoma of the bronchus 8 by 5 by 4.5 cm, and bronchiectasis and atelectasis of the lung were present distal to the growth (fig 390).

Comment—This was the largest adenoma of the bronchus that we have ever seen. The intrabronchial portion made up only a small part of the tumor. It would have been impossible to have attempted treatment by any means except pulmonary resection.

CASE 5—A white man forty-two years of age registered at the Clinic on August 30, 1945. He had had cough and hemoptysis for about four months. He had no other complaints and his general health appeared to be excellent.

Roentgenographic study of the thorax gave negative results. Values found on studies of the blood were within normal limits. Bronchoscopy revealed a large polypoid lesion in the main bronchus of the left lung. On biopsy this proved to be an adenoma of the bronchus. Operation was advised. Because of the location of the tumor it was necessary to perform pneumonectomy. This was carried out in the usual way. The postoperative course was completely uneventful. The patient was dismissed from the hospital on the twelfth postoperative day.

Comment—This case is interesting because it indicates that serious conditions can occur even in the absence of roentgenologic evidence of disease



Fig 391 (Case 6) —a and b Tumor mass and atelectasis of the right lower lobe of the right lung distal to the adenoma

CASE 6—The patient, a white man forty eight years of age, registered at the Clinic on January 31, 1944. He had had recurrent bouts of pneumonia, cough and hemoptysis for about sixteen years. Studies of the blood gave results within normal limits. Roentgenographic and bronchoscopic studies of the thorax revealed a tumor in the right lower lobe bronchus (fig 391 a and b). Microscopic examination of tissue removed through the bronchoscope revealed the tumor to be an adenoma of the bronchus.

Operation was advised and on February 21, 1944 lobectomy and individual ligation of the hilar structures were performed. The operation was difficult because it was extensive and many vascular adhesions were present. A transfusion of 2500 c.c. of blood was administered during the operation. The adenoma and the results of obstruction are shown in figure 392.

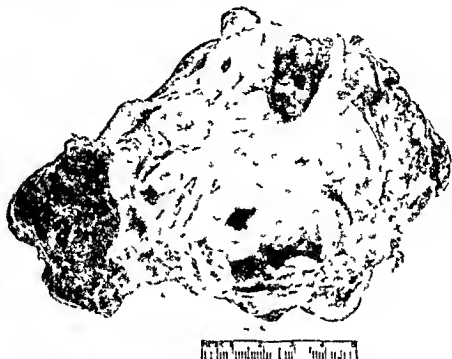


Fig. 392 (Case 6) —Surgical specimen showing adenoma of the bronchus and destruction of the lung distal to the obstruction.

After operation empyema developed and open drainage was necessary on March 30, 1944. The cavity was filled in with granulation tissue. The patient returned for re-examination in September, 1944, and at that time his condition was good.

Comment—This case illustrates that symptoms may be present for a long time in cases of bronchial adenoma. It was unfortunate that the operation was delayed until such extensive damage had occurred and a difficult and dangerous operation was necessary. If the operation had been performed earlier it would have been a much easier and safer procedure.

CASE 7—The patient, a woman forty-one years of age, registered at the Clinic on December 9, 1943. She had had pleuritic pains in the left side of the thorax for about thirteen years and a chronic nonproductive cough until six months before she was examined. At the time of examination she stated that she had

— 2 — OF BLOOD (500 C.C.)

Results of laboratory studies at the Clinic were negative except for the recent



Fig 393 (Case 7) Lesion of the hilum of the left lung



Fig 394 (Case 7) —Adenoma completely obstructing the left upper lobe bronchus

genograms of the thorax which revealed a lesion in the hilus of the left lung (fig 393). Bronchoscopy was performed. It was impossible to visualize the tumor. However, a deformity was noted in the upper lobe bronchus and it appeared to be caused by extrabronchial pressure. It was the bronchoscopist's impression that this patient might have an extrabronchial tumor.

In spite of the negative findings at bronchoscopy, operation was advised and on December 20, 1943, the operation was performed. A tumor was found in the upper lobe of the left lung at the hilus. It was a firm, hard, rounded tumor mass. Pneumonectomy was performed in the usual way. On pathologic examination the mass was found to be an adenoma of the bronchus, 4.5 cm in diameter (fig 394). Patient's postoperative course was completely satisfactory and she was dismissed from the hospital on the fifteenth postoperative day. At a later examination she appeared to be in excellent health and had no symptoms.

Comment—In this case it was impossible to visualize the tumor and obtain tissue for pathologic examination before operation. The history and roentgenographic findings were compatible with the diagnosis of carcinoma of the lung or adenoma of the bronchus. It was technically impossible to remove the upper lobe and pneumonectomy was performed without difficulty. This case illustrates the importance of advising thoracic exploration in cases in which the presence of tumor of the lung is suspected even when it is impossible to obtain pathologic proof of the nature of the lesion before operation.

TOTAL GASTRECTOMY: REPORT OF A PATIENT SURVIVING FOR EIGHT YEARS

JAMES F WEIR

PARTIAL gastrectomy is employed frequently in the treatment of both benign or malignant gastric lesions. Total removal of the stomach is undertaken much less frequently because it is a more hazardous procedure. However, it is being used more and more frequently. Because malignant disease tends to be more extensive and requires more radical procedures for cure, total gastrectomy is used more often in malignant than in benign disease. In comparison to the number of operations which are performed for malignant and benign gastric disease, the number of total gastrectomies is relatively small.

In 1933 Roeder collected eighty-eight cases from the literature. In 1942 Joll and Adler collected another forty-seven cases in which gastrectomy was performed successfully and added two of their own in which the patients had survived for three years and a few months. In 1943 Farris, Ransom and Collier reported that from 1937 to 1943 twenty-four patients survived this operation and discussed the metabolic study in one case in which the patient had lived for four years and seven months.

At the Clinic total gastrectomy was performed in twenty cases from 1917 to 1934. From 1935 to 1944 the operation was performed in seventy-six cases for malignant disease and in nine cases for benign disease. Two of the patients who had benign disease were operated on in 1935. One of these is known to have been disabled five years later, the other had suffered from chronic ulcerative colitis before gastrectomy for a large sessile polyp and pulmonary tuberculosis developed subsequent to the operation. He has improved markedly and at the time of this report is working part time. The patient whose case is presented herein was operated on in 1937 and recently has been under observation.

REPORT OF CASE

The patient, a man twenty-five years of age, first was examined at the Clinic in November 1925 because of a gastric disorder. Symptoms which had had their onset when he was fourteen years of age had been characterized by epigastric distress one and a half to two hours after meals. He had obtained relief by ingestion of food or alkalies and by vomiting. The attacks of epigastric distress had occurred chiefly in the spring and fall seasons or after dietary indiscretions and had persisted for from a few days to two or three weeks.

On examination at the Clinic the patient weighed 165 pounds (74.8 kg). Urinalysis and blood count gave normal results. Gastric analysis after an Ewald

meal revealed total acidity of 80 clinical units and free hydrochloric acid of 60 clinical units (Topfer's method) and 290 c.c. of gastric contents were aspirated. Roentgenologic examination of the stomach revealed a duodenal ulcer which caused marked obstruction. After preoperative preparation exploration was undertaken. A large duodenal ulcer which perforated onto the under surface of the liver and gallbladder and produced marked obstruction was found. Posterior gastroenterostomy was performed.

Following dismissal from the Clinic the patient was well for eight years. During the next year he experienced distress at 9 to 10 o'clock in the evening and in the following two years this distress occurred about three hours after meals and was relieved when he took alkalis and food. In the four weeks before his next visit in May, 1937, when he was thirty six years old, his distress had been much worse and he had become dizzy and weak and had had to spend considerable time in bed.

On examination his weight was 160 pounds (72.6 kg). Moderate pallor was noted. The level of hemoglobin in the blood was 60 gm per 100 c.c., erythrocytes numbered 3,110,000 per cubic millimeter of blood and leukocytes, 10,200. Fractional gastric analysis after an Ewald test meal revealed total acidity to be 4, 4, 6 and 12 clinical units. No free hydrochloric acid was obtained. A total of 335 c.c. was aspirated from the stomach. On roentgenologic examination of the stomach the superior portion of the duodenum was found to be deformed, the gastro-enteric stoma was free and a large ulcerating lesion was present high on the posterior wall of the stomach. On gastroscopic examination the lesion appeared to be infiltrating in type. It bled easily. The gastroscopist considered the lesion to be probably malignant.

At exploration the gastro-enteric anastomosis was found to be in good condition. The lumen of the duodenum was contracted. Multiple lesions were felt in the stomach: one was high on the lesser curvature, just below the cardia, and another which measured from 3 to 4 cm. in diameter was high on the posterior wall and was perforating. The surgeon could not determine whether the lesions were benign or malignant. Total gastrectomy was performed after the gastro-enteric anastomosis was disconnected. The duodenum was cut across and the open distal end was turned in and sutured. A loop of jejunum about 2 to 2½ feet (60.9 to 76.2 cm.) from its origin was brought anterior to the colon and anastomosed to the end of the esophagus. An entero-anastomosis between the two limbs of the jejunum was established. Pathologic examination disclosed that 1 cm. of duodenum and 25 cm. of stomach had been removed. In the latter were three inflammatory ulcers. The largest measured 4 by 2 by 1 cm. and had perforated the smallest was 1 cm. in diameter.

The patient's postoperative course was stormy. Pneumococcal pneumonia developed and empyema on the right side made open drainage necessary. He was discharged from the hospital forty three days after gastrectomy had been performed and he was permitted to return home nine days later. At that time he was gaining weight, eating three meals a day and drinking milk between meals. His lowest recorded weight was 139 pounds (63 kg.).

When the patient was observed in November, 1937, he weighed 159 pounds (72 kg.). He felt well, had an excellent appetite and was eating three moderate-sized meals daily and three additional lunches. No discomfort was noted. He returned yearly for examination until 1942.

The patient was examined again in 1945. His weight averaged 160 pounds (about 73 kg.). He felt well and earned on his farm work without difficulty. His appetite was good and he stated that he experienced hunger. He was able to eat most foods in normal quantities. He got along satisfactorily with three meals a day but was in the habit of lunching between meals and at bedtime. He found

this lunching advisable when performing heavy work. It was necessary that he limit the size of his meals slightly and avoid rich foods. When he ate large meals he had slight epigastric distress, nausea, palpitation, sweating, lightheadedness and weakness from which relief was obtained by rest. These symptoms are characteristic of a mild dumping syndrome and were of infrequent occurrence. He did not tolerate milk well but butter and cream caused no difficulty. His bowels moved regularly one to two times a day. Occasional mild looseness of the stools occurred but no more frequently than before operation.

In the fall of 1939 the patient had soreness and redness of his tongue for three or four weeks but when he was seen in May 1940 no objective atrophy was noted though slight redness was present. No atrophy was noted at examinations in 1941 and 1942. Some soreness of the tongue was again noted in the fall of 1944. At his last examination in June 1945 definite atrophy of the papillae at the edges of the tongue was present. The patient had no paresthesias vibra

TABLE 1—POSTOPERATIVE LEVEL OF HEMOGLOBIN AND ERYTHROCYTE COUNT IN A CASE IN WHICH TOTAL GASTRECTOMY WAS PERFORMED

Year	Hemoglobin gm per 100 cc of blood	Erythrocytes per cu mm of blood	Remarks
1937	12.5	4,780,000	
1938	11.6	4,000,000	
1939	9.8	3,500,000	Hypochromic anemia
1940	11.9	4,220,000	
1941	11.9	3,430,000	
1942	12.3	4,180,000	
1945	13.2	3,220,000	Moderate macrocytosis. Some right shift in polymorphonuclear leukocytes. Mean diameter of erythrocytes 8.1 μ .

tion sense in his extremities and reflexes were normal. His hair was becoming white when he was forty-five years of age but this was a family characteristic. Osteoporosis was not demonstrable in long bones on roentgenographic examinations in 1941 and 1945.

In 1945 the level of calcium was 9.3 mg and phosphorus 4.24 mg per 100 cc of serum. Serum protein was 7.26 gm per 100 cc and the albumin globulin ratio was 1.57 to 1.0. The level of total lipoids in the blood was normal. The values for hemoglobin, erythrocyte count and results of study of blood smears since gastrectomy are given in table 1. In these eight years he had taken iron occasionally but none had been taken for some time before any of his examinations at the Clinic. In general the patient had maintained a fairly normal blood picture until the last examination when macrocytosis was found. On sternal aspiration the bone marrow revealed no megaloblastic changes. Because of the macrocytosis liver extract was prescribed.

COMMENT

Total gastrectomy is a heroic procedure and when successfully performed it gives rise to some interesting physiologic problems. These derive from the absence of the functions performed by the stomach. This patient's appetite was excellent and he stated that he experienced hunger. Roeder's patient also reported experiencing this sensation. Hunger is considered to result from powerful contractions of the gastric musculature which is obviously absent in this patient. Possible



Fig 395—Esophagojejunal anastomosis Absence of dilatation of both proximal and distal loops of the jejunum may be noted

explanations of this phenomenon are that he misinterpreted the sensation he experienced, that sensation of hunger was due to the development of a conditioned reflex or that the phenomenon of hunger consists of more than the so called hunger contractions of the stomach.

Disturbance of reservoir function is present occasionally in cases in which partial gastrectomy is performed Berkman and Heck have recently discussed this problem The patients complain of quick filling and discomfort and at times it is difficult to get them to take adequate amounts of food and loss of weight ensues. Usually, however,

if they receive encouragement, are persevering and eat five meals of increasing amounts daily, they soon become accustomed to the new situation and the gastro intestinal tract will accommodate an adequate intake of food. When patients have undergone total gastrectomy discomfort and loss of appetite and weight are much more prominent complaints than after partial gastrectomy and some patients never seem to make satisfactory adjustment. In the case reported herein the patient adjusted promptly and has been able to take sufficient food in three meals to maintain his normal weight and carry on moderate activities.

A factor that at times interferes with adequate intake of food after either partial or total gastrectomy is the occurrence of the "dumping" syndrome first described by Hertz. Those suffering from this disorder complain of discomfort immediately after eating nausea weakness pallor palpitation tachycardia perspiration lightheadedness and faintness. The symptoms persist for twenty to thirty minutes are usually more severe after breakfast and are eased when the patient lies down. In some instances these symptoms gradually disappear but in others they persist and at times are disabling. The cause of these symptoms has not been explained clearly but apparently they are the reflex effect of too great and too rapid distention of the jejunum by the ingested food. These symptoms occurred only to a mild degree in this patient and only when he overate. Certain foods particularly milk seemed to be more prone to bring on the symptoms than others.

In general this patient suffered little from loss of the reservoir function of the stomach. Roentgenologic examination showed no significant dilatation of the intestine at the site of the anastomosis to suggest that the intestine changed in taking over the function of storage of food (fig 895).

Loss of triturating function evidently did not produce any significant effects. In animals food may at times appear in feces in an undigested state, but this has not been noted in this case. The patient has been careful to masticate his food thoroughly.

Disturbance of digestive function may be important. The digestive functions of pepsin and hydrochloric acid must be taken over by the pancreatic and intestinal enzymes. Ivy has shown that in gastrectomized animals the intake of meat may cause diarrhea and that increased amounts of meat milk and bread are required to maintain normal weight. Metabolic studies on human beings after partial or total gastrectomy are not numerous. Steatorrhea has been noted in some reports. Farris Ransom and Collier in 1943 reported a metabolic study in a case five years after total gastrectomy. They found no excess loss of fat and a normal coefficient of digestibility of protein. In a study¹² of intake and excretion recently made at the Clinic on patients after partial gastrectomy variable loss of fat in the stool

above normal has been found and the amount of nitrogen lost was increased in an occasional case. In this case no satisfactory metabolic data are available. However, no clinical steatorrhea occurred and the patient's general nutrition was good, indicating that no clinical disturbance resulted from loss of digestive function of the stomach.

The stomach because of its secretion of hydrochloric acid aids in the absorption of calcium and iron. In this case calcium metabolism was not disturbed as evidenced by absence of osteoporosis and normal content of calcium and phosphorus in the serum. Many authors have reported that hypochromic anemia occurred in some cases in which either partial or total gastrectomy was performed and that the condition was controlled readily by administration of iron. In some cases, however, patients do not respond to treatment with iron or even liver extract. This patient had slight anemia at times and therefore he took iron intermittently. In general, the hemoglobin content of his blood has been maintained near normal levels with little effort.

On the basis of Castle's hypothesis, total removal of the stomach usually would be presumed to produce a marked effect on hematopoiesis because of failure of elaboration of the intrinsic factor. In animals it has not been possible to produce macrocytic anemia by total gastrectomy even though various dietary modifications have been tried. Hyperplasia of the bone marrow has been found, however. Numerous reports have appeared in the literature on occurrence of pernicious anemia or pernicious anemia like syndromes after partial or total gastrectomy. Meyer suggested that pernicious anemia does not develop in many of these cases because the patients do not live long enough. Pernicious anemia has been reported by Meinertz to develop as late as sixteen years and by Ellis fifteen years after subtotal gastrectomy for carcinoma and by Denning and Breitenbach seven years after total gastrectomy for gastric ulcer. As a rule liver extract has controlled this syndrome satisfactorily. Only at the last examination of the patient has there been any significant macrocytosis. Slight glossitis occurred at times but it was only at his last examination that any atrophy of the tongue was noted. Neurologic signs were not demonstrable. Because of changes in the blood and atrophy of the tongue administration of liver extract was considered advisable for the first time eight years after operation.

SUMMARY

Total gastrectomy is a hazardous procedure which is usually undertaken for malignant disease of the stomach. In some cases of benign disease, however, this procedure has been carried out. The subsequent course in benign disease offers a better opportunity for study of the physiologic effects on the human organism. A case is reported in which the patient survived in clinically good health for eight years.

after this operation and some comments on total loss of gastric functions are made. The chief manifestation of this loss to date in this case has been in regard to hematopoiesis. A mild macrocytic anemia with attendant slight atrophy of the tongue developed.

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RESECTION OF THE HEAD OF THE PANCREAS AND DUODENUM: OPERATIVE TECHNIC

JOHN M. WAUGH

In the past five years forty two patients have undergone resection of the head of the pancreas and duodenum at the Clinic for carcinoma islet cell tumor or pancreatitis. In five of these cases total pancreatectomy was performed, in three of the five for islet tumor, in one for carcinoma and in one for diffuse chronic pancreatitis with calcification and intractable pain. Six patients had partial pancreatectomy for chronic pancreatitis with or without calcification or obstructive jaundice, but all had intractable pain which was not amenable to more conservative measures. Of the remaining thirty one patients

TABLE 1—RADICAL RESECTION OF HEAD OF PANCREAS FOR CARCINOMA
OPERATIVE MORTALITY

Site of Lesion	Operation in	Patients	Hospital Deaths		
			Number	Per Cent	
Head of pancreas 17 cases	1 stage	13	1	7.7	11.8
	2 stages	4	1	25.0	
Ampulla 10 cases	1 stage	7	2	28.6	30.0
	2 stages	3	1	33.3	
Duodenum and stomach 3 cases	1 stage	3	1	33.3	
Total		30	6	20.0	

twenty eight underwent partial pancreatectomy because of carcinoma of the head of the pancreas or ampulla of Vater, two because of carcinoma of the duodenum and one because of carcinoma of the stomach with involvement of the head of the pancreas. The operations entailed removal of the duodenum and head of the pancreas and in the cases in which total extirpation was performed removal of the spleen as well as the entire pancreas was included.

In a recent analysis by Clagett and me of the first thirty resections done for carcinoma at the Clinic, the practicability of the technic to

be described which I had used in three cases seemed evident. Of the thirty patients all but six survived operation resulting in a hospital mortality rate of 20 per cent (table 1). Thirteen resections for carcinoma of the head of the pancreas were performed in one stage with one death (a hospital mortality rate of 7.7 per cent).

STUDY OF METHODS EMPLOYED IN THE FIRST THIRTY CASES

Special study was made of the methods used to dispose of the pancreatic stump and biliary system and to restore gastro intestinal continuity in the first thirty cases in order to uncover those methods which were apparently most often successful. The following is a brief summary of the deductions it seemed proper to make.

Pancreatic Stump.—In seventeen cases the stump and duct were obliterated by suture and in the last thirteen the end of the pancreas was implanted into the jejunum. Although the percentage of hospital deaths in these two groups differed little, it is likely that experience will show that restoring the pancreatic secretion to the intestine will actually lower the mortality rate as obliteration of the pancreas is more difficult and hazardous. Certainly on the score of maintaining nutrition postoperatively it is preferable to anastomose the pancreas to the intestine. Whether the end of the pancreas is brought to the end or the side of the jejunum is a matter for the individual surgeon but I prefer the end to end anastomosis which for me is technically easier and more logical than the end to side. If the latter method is used either an extra step is required to close the end of jejunum or if an end to end choledochojejunostomy is anticipated its execution is more difficult than an end to end pancreaticojejunostomy followed by end to side choledochojejunostomy.

Biliary System.—In four cases choledochogastrostomy was employed, in twenty choledochojejunostomy. In twelve of these twenty four complementary cholecystostomy was performed. In two cases both cholecystojejunostomy and choledochojejunostomy were performed and in five cholecystojejunostomy or cholecystogastrostomy with ligation of the common duct was used. One of the five patients in the latter group required a secondary choledochojejunostomy and is included in two of the groups mentioned. The mortality in the cases in which the gallbladder was employed in the anastomosis was 40 per cent as compared to a mortality of 15.4 per cent in the twenty six cases in which the common duct was utilized. This evidence favors the utilization of the common duct in the anastomosis as it seems to give more direct biliary decompression than the gallbladder. When a two stage procedure is employed, however, and also when the common duct is not dilated the gallbladder is preferable. Complementary cholecystostomy seems wise as a safety measure when the common

duct is anastomosed to the gastro-intestinal tract in case of temporary postoperative obstruction due to edema or inflammatory reaction around the choledochojejunostomy.

Gastro-intestinal Continuity.—Although practically every conceivable method of gastrojejunostomy was used one or more times, the postcolic antiperistaltic method was the favored technic and carried the lowest mortality. It is possible that the method of restoration of the gastro-intestinal tract had no bearing on the mortality rate, but the difference between certain methods was striking. For example, fifteen patients had an antecolic anastomosis with five deaths (a mortality rate of 33 per cent), as compared to fifteen patients who had

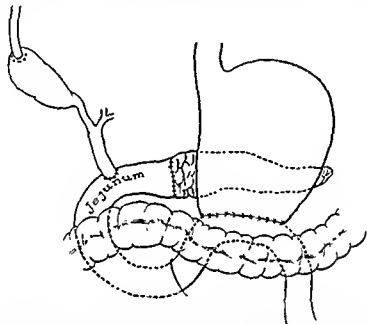


Fig 396.—Technic for restoration of gastro-intestinal tract, biliary and pancreatic ducts following resection of duodenum and head of pancreas. (End-to-end pancreaticojejunostomy, end-to-side choledochojejunostomy, end-to-side, postcolic, antiperistaltic gastrojejunostomy.)

postcolic anastomosis with one death (a mortality rate of 6.7 per cent). Twelve of the thirty patients had an isoperistaltic gastrojejunostomy with four deaths (a mortality rate of 33 per cent) whereas eighteen had an antiperistaltic anastomosis with two deaths (a mortality rate of 11.1 per cent).

Comment.—From these data it seems reasonable to propose whenever certain anatomic situations do not contraindicate that end-to-end pancreaticojejunostomy with end-to-side choledochojejunostomy and end-to-side postcolic, antiperistaltic gastrojejunostomy (fig. 396) be employed for restoration of the pancreatic and biliary ducts and the gastro-intestinal system. This technic more or less isolates the biliary

and pancreatic systems so that food and the gastric secretions are shunted distally. This isolation may prove to be a factor in preventing cholangitis. Furthermore, if recurrence of a malignant lesion should supervene, it would not be likely to obstruct the gastroenterostoma.

PREOPERATIVE PREPARATION AND CHOICE OF ONE-STAGE OR TWO STAGE PROCEDURE

The patient who has obstructive jaundice which is believed to be caused by carcinoma in and about the head of the pancreas deserves full consideration from the standpoint of proper and adequate preoperative preparation. It may require as long as two weeks of concerted effort to place the patient in optimal condition. Anemia should be corrected by administration of whole blood. A high carbohydrate high protein low fat diet is in order and if a sufficient quantity of food cannot be taken orally the diet should be supplemented with intravenous administration of glucose and protein digest. Vitamin K should be administered whether the prothrombin time is high or not and in addition vitamins B and C should be given.

If the prothrombin time is elevated and does not respond to liberal use of vitamin K, usually considerable liver insufficiency is present and resection if feasible should be undertaken in two stages. The first operation should be limited to determining the nature and operability of the obstructing lesion and the simplest method of decompressing the biliary tract should be used. This will usually be cholecystojejunostomy. Most patients however can be so well prepared that a one stage procedure is safe and advisable and it has certain advantages. The malignant lesion is eradicated at an earlier date than in the two stage procedure. The operation in one stage is usually easier technically and the patient is spared the discomfort, expense and risk of a second operation. There are certain patients however who are in such poor condition when they come for treatment that a two-stage procedure is obligatory and by careful preoperative analysis this group can as a rule be determined with little difficulty.

ANESTHESIA AND INCISION

The choice of anesthetic agents at the Clinic has been nitrous oxide, oxygen and ether or cyclopropane and curare. An intratracheal tube is employed with both combinations. Glucose is slowly administered intravenously throughout the procedure which on the average takes about three hours of anesthesia and from 500 to 1500 cc of blood. The quantity of blood given depends on the requirements of the individual patient. A right rectus incision made from the xiphoid process to an inch (2.5 cm) below the umbilicus with lateral retraction of the muscle will usually give excellent exposure.

OPERATIVE DIAGNOSIS AND RESECTABILITY

Before proceeding with an operation of the magnitude of partial or total pancreatectomy, it behooves the surgeon to satisfy himself first, by careful exploration, that the operative risk is warranted. If a malignant lesion of the head of the pancreas or the ampulla is suspected clinically, this should be verified by biopsy. Often the characteristic malignant infiltration is so obvious that no microscopic confirmation is necessary, but the poise and peace of mind which come to the surgeon when the diagnosis of a malignant lesion is confirmed by pathologic examination of fresh frozen tissue is well worth the added few minutes it may require to obtain this confirmation.

A small tumor may be felt at the papilla of Vater projecting into the duodenum, or there may be an ulcerating lesion at this point. Removal of a specimen from either of these may be readily done transduodenally. The common bile duct should be explored carefully and occasionally malignant tissue can be obtained with the common duct scoop or curet. If there is still a question as to the presence of a malignant lesion, a good solid wedge of tissue should be removed from the part of the pancreas which is most suspected of harboring a malignant lesion. If the result of examination is positive, the diagnosis is settled, if negative, it by no means rules out the presence of carcinoma.

After the diagnosis is verified, either by the local findings or microscopic examination, the surgeon must be certain that the disease is still localized enough to warrant resection. The liver may have been found to contain a metastatic lesion, peritoneal implants may have been observed or the local mass is so large and fixed that the situation obviously is hopeless without the necessity for the precautions mentioned in the previous paragraph. The mesentery of the small intestine should be inspected for metastatic nodules, as the large nodes at the radix may be involved and multiple retrograde metastatic lesions may be found near the intestine in the periphery of the mesentery even before involvement of the liver is apparent. It would seem that there is little justification for undertaking this extensive procedure as a known palliative procedure so every precaution should be taken to rule out metastasis before starting mobilization of the pancreas and duodenum.

DETAILS OF OPERATIVE TECHNIC

The duodenum and head of the pancreas are mobilized by incising the peritoneum lateral to the duodenum and gently elevating it. This maneuver will expose the superior mesenteric vein and the surgeon can satisfy himself that it is not involved and that it will be possible to remove the pancreas cleanly from the vein. Extension of the carcinoma around this vein probably most often contraindicates an at

tempt at resection when all other factors appear favorable. This point therefore, must be settled before proceeding.

The stomach is severed between Payr clamps at the juncture of the middle and lower third after the vessels along the lesser and greater curvatures are ligated at the proposed line of section. The distal portion of stomach is mobilized by severing the gastrocolic ligament and the right gastric and gastroduodenal arteries are ligated and severed. Care is taken not to injure the hepatic artery which frequently is close to the head of the pancreas. The common bile duct is severed just proximal to its entry into the pancreas and well above any carcinomatous involvement after it is dissected free from the superior mesenteric vein. The bile is removed with the mechanical aspirator and the tarry bile is expressed from the gallbladder by gentle pressure and is evacuated.

A point is selected in the body of the pancreas well to the left of any gross involvement in the head and by means of a grooved director or the finger, the posterior wall is gently separated from the underlying vessels and severed. A clamp is left on the right portion of the pancreas and the bleeding vessels are ligated separately on the cut surface of the left portion which will be preserved for implantation into the jejunum. The right portion of the pancreas is then gently elevated and rotated to the right to bring into view the superior mesenteric vessels. The short veins between the pancreas and superior mesenteric vein are carefully severed between clamps and secured with transfixed ligatures of fine silk. The uncinate process is likewise freed from the vein and the inferior pancreaticoduodenal artery and vein are severed and ligated. Care is taken to preserve the middle colic vessels.

After the pancreas and duodenum are mobilized completely from their vascular attachments gentle traction on the latter will permit the upper part of the jejunum to slide under the superior mesenteric vessels through the opening normally occupied by the third portion of the duodenum. The upper part of the jejunum is then mobilized sufficiently to permit anastomosis to the end of the pancreas and common duct without tension. Care is taken to preserve the blood supply to this segment of jejunum and the intestine is severed at the site selected which will usually be a few centimeters beyond the ligament of Treitz.

With the jejunum now occupying a position similar to that of the normal duodenum an end to end anastomosis is effected between the pancreas and jejunum with two rows of interrupted silk sutures. The pancreas after the anastomosis is completed projects into the jejunum for about 1 cm. An end to side anastomosis is then made if conditions permit between the common bile duct and jejunum with two rows of interrupted silk sutures at a convenient point in the jejunum distal to the pancreaticojejunostomy (usually 3 or 4 inches 7.6 to 10 cm).

The root of the mesentery is then closed around the jejunum to prevent internal herniation and a postcolic end-to-side antiperistaltic gastrojejunostomy is used to re-establish the gastro-intestinal continuity. An inner row of running chromic catgut and an outer row of interrupted silk sutures are utilized.

A Levine tube is passed into the proximal limb of the jejunum and constant suction is applied. A complementary cholecystostomy is performed and the tube is removed in two or three weeks. The pancreatic region is drained through a stab wound below the right costal margin with Penrose drains.

POSTOPERATIVE CARE

The postoperative course is usually smooth and frequently there is surprisingly little febrile reaction. Constant suction is maintained on the Levine tube in the proximal limb for from three to five days, unless complications ensue which indicate longer drainage. Fluids are given by mouth forty-eight hours after operation and gradually the usual gastric resection diet is given. The diet is gradually increased to the ambulatory ulcer diet which is continued for one month. Fluids are administered by vein to maintain proper electrolyte balance to make up for any unusual loss of bile and fluid from the upper part of the intestinal tract. Anemia and protein deficiency are corrected with whole blood and protein digests. Administration of vitamin K, as well as vitamins B and C, are continued for approximately three weeks by which time the elevated serum bilirubin will be approaching normal figures.

Both penicillin and sulfadiazine are given in adequate doses for approximately one week. From 5 to 10 gm. of sulfathiazole is placed intraperitoneally at the completion of the operation so that sodium sulfadiazine is not administered intravenously for about forty-eight hours. The Penrose drains and cholecystostomy tube are removed about two weeks after operation.

The patient should be examined at frequent intervals during the immediate postoperative period and occasionally later for glycosuria and elevation of the blood sugar because an occasional patient may have transient difficulty in this respect. One of the forty-two patients operated on at the Clinic developed diabetes one year after resection without antecedent difficulty.

Although with re-implantation of the pancreas into the jejunum loss of fat in the feces is much reduced as compared to what occurred in the early cases in which the pancreatic stump was obliterated, some patients will require pancreatin to control the bulky fatty numerous stools and thus permit them to maintain or gain weight. The dosage will vary with the individual patient, but may run as high as 30 tablets daily in extreme instances.

These patients have been singularly free of cholangitis or bouts of chills and fever with recurrent jaundice, if the malignant lesion has not recurred

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TOTAL AND SUBTOTAL COLECTOMY WITH REVIEW OF SEVENTY-TWO CASES

CLAUDE F. DIXON AND RAYMOND E. BENSON

IN the surgical treatment of disease of the colon it is occasionally necessary to extirpate long segments of this organ. When the entire colon and rectum are involved by the diseases to be described total colectomy is indicated. When some portion of the colon or rectum remains but a segment greater than a half of the length of the normal colon is removed, the operation is referred to as subtotal colectomy.

Some years ago, in the time of Sir Arbuthnot Lane, the colon was thought to be frequently the site of origin of systemic diseases. Colectomy was advocated for such a wide variety of conditions as acne vulgaris and other skin diseases, arthritis, menstrual disturbances, "female trouble," disturbances of vision and constipation of the type which is now recognized as being functional in origin. At the present time the indications for colectomy are much more clearly defined than they were then and it is only in an occasional instance that the operation is necessary. It is the purpose of this paper to define the indications for colectomy and record our experience with this procedure. The present report is based on a series of seventy-two consecutive cases in which total or subtotal colectomy was performed by the senior author between 1929 and 1945.

In general, colectomy is indicated in only those conditions in which long segments of the colon are involved by local pathologic process. Systemic diseases and conditions elsewhere in the body remotely related to the large intestine rarely, if ever, constitute sufficient indication for the operation. In the seventy-two cases of this series there are thirty-two cases of megacolon, nineteen of polypoid disease of the colon and seventeen of chronic ulcerative colitis. In three additional instances multiple carcinomas of the colon (one case), extensive diverticulosis and diverticulitis (one case) and multiple fecal fistulas arising from different segments of the colon (one case) necessitated colectomy. In a final case a long segment of defunctionalized colon was extirpated to remove a purposeless mucous fistula.

MEGACOLON

Megacolon is primarily a disease of childhood. Occasionally the idiopathic form of the disease is also encountered in adults. The outstanding symptom presented by patients with this affliction is constipation. Spontaneous intestinal movements are very infrequent. Constipation is often noted shortly after birth. If the megacolon is not

corrected these children usually do not develop normally. Because of the abdominal distention they are "poor eaters" and are malnourished. Flaring of the margins of the ribs and deformities of the thorax from long continued abdominal distention may result. More serious than these complications are the repeated obstructive crises with vomiting and tremendous distention of the abdomen to which such patients are subjected. Occasionally these episodes are due to a long mesentery with associated volvulus of the elongated and enlarged bowel but often there is no mechanical obstruction aside from fecal impaction.

Not all persons who have megacolon require surgical treatment. In the milder form of the disease medical treatment may give satisfactory results. In another group of cases an obstructive band or stricture or diaphragm will be found in the lower portion of the rectum. Correction of this may entirely alleviate the condition. When such obstruction is of many years standing however the dilatation, hypertrophy and atony of the proximal portion of the bowel are often irreversible and colectomy will be required in addition to relief of the rectal obstruction.

Sympathectomy has been advocated as a method of treatment of persons who have this disease. In our experience it is not a satisfactory procedure. In cases in which the disease is advanced, sympathectomy seems of little value. In cases in which the disease is in an earlier stage sympathectomy is often of striking immediate benefit but unfortunately if these patients are followed for a sufficient period after operation it will be found that from one to several years later many have a complete recurrence of the condition. Bilateral lumbar sympathectomy is also disadvantageous for males because of its possible deleterious effect on the generative organs. In the present series there were two patients who stated that they had undergone sympathectomy without benefit. Colectomy provided a good result for both.

In cases of megacolon the mesentery of the colon is always long and redundant. This apparently results from the long continued pull of the heavily distended colon on its attachments. Because of the unusual length of the mesentery colectomy is more easily accomplished in these cases than in any other condition. The entire colon is usually easily delivered into a low left rectus incision. We have noted on many occasions that the lymph nodes in the mesocolon or mesentery are unusually enlarged in cases of megacolon. When excised the nodes show simply the changes characteristic of chronic inflammation. The bowel itself is the site of a most unusual alteration. The normal haustrations are completely obliterated. The bowel is enormously dilated and sometimes (when the patient is an adult) is 8 to 10 inches (20 to 25 cm) in diameter (fig. 397). The wall of the bowel is thickened and leathery in the involved segment. If the disease does

not involve the entire colon, that portion which lies proximal to the involved segment will also be dilated but in this portion the walls are thin and haustrations are present. This dilatation is secondary to chronic obstruction and is not a part of the disease process.

In the performance of colectomy for megacolon a lower left rectus incision is commonly employed. The colon is removed from a point immediately below the diseased region around to a point well proximal to the involved segment. It is not necessary to remove extra lengths of colon in order to be able to approximate the remaining

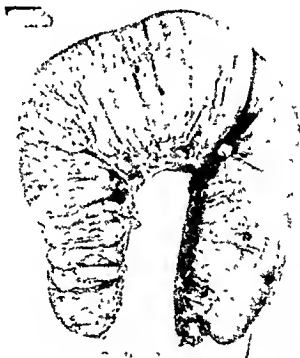


Fig 397.—Megacolon, showing enormous dilatation and hypertrophy of entire colon. The specimen was removed from a white man, twenty-three years of age, who had suffered from severe obstipation from infancy. Note the enlarged lymph nodes in the mesocolon.

ends. In cases of megacolon, because of the increased length of the mesentery and the resultant mobility of the bowel, a remaining end of sigmoid can be approximated easily to any other portion of the colon with the possible exception of the splenic flexure in occasional cases.

Removal of the mesocolon is not indicated for therapeutic reasons but colectomy is facilitated if the mesocolon is removed. In so doing the large arteries and veins of the mesentery are severed close to their point of origin rather than distally where they have branches and ramifications which require many ligatures. After colectomy primary

anastomosis may be performed and in many cases this plan has been successfully consummated. It is better in our opinion, however, to exteriorize the remaining ends of the intestine and close the enteric stoma later. In these cases in which the patients are in poor condition, the extra time necessary to perform primary anastomosis is often not justified. With the newer adjuncts to closure of an enteric stoma which we have previously described* the closure of the stoma at the second stage is a relatively minor procedure which is associated with a very low risk.

A more stringent reason for employing the exteriorization procedure is found in those instances in which megacolon involves the rectum and rectosigmoid as well as more proximal segments. Permanent colostomy is not necessary for such patients. If the proximal diseased segments are extirpated and the rectosigmoid and rectum are defunctionalized for a time as necessarily occurs in the exteriorization procedure a remarkable change takes place. After the fecal stream has been diverted for several months from the enlarged rectum and rectosigmoid these segments shrink to approximately normal or nearly normal size. Their walls become soft and thin as in normal bowel and radiologically, proctoscopically, and by direct inspection they appear normal. After the stoma has been closed and the fecal stream once more passes through these formerly diseased segments a small degree of recurrent dilatation may take place. It has been our repeated observation, however, that so far as the function of the bowel is concerned these patients are normal.

In a few cases after resection, whether it be done in one or two stages, a temporary distressing type of intestinal dysfunction will develop. This may first appear several weeks after operation. It is characterized by abdominal cramping pain and short periods of abdominal distention and constipation. Intermittently there may be diarrhea. Vomiting sometimes occurs. These episodes may be very transient but occasionally they will last for many days. Often they are precipitated by an infection of the upper part of the respiratory tract or some other type of infection. Plain roentgenograms of the abdomen show moderate dilatation of both small and large bowel which is often segmental. This distressing state is not due to organic obstruction of the bowel. It seems to be a spasm and functional derangement of the normal peristaltic activity of the intestinal tract. It may be that the intestine which has been accustomed to working for years against a high pressure gradient as in megacolon must undergo a period of readjustment after the obstruction is relieved. During these periods of intestinal dysfunction the administration of belladonna in adequate doses often brings early and adequate relief. To prevent this disturbance we have recently advocated the routine administration of belladonna for several months after conclusion of the operation.

The average age of the thirty-two patients who had megacolon in this series was 14.4 years. Twenty-five were twenty-one years of age or younger. The youngest patient was one and a half years of age. Twenty-seven patients were male and five were female, a ratio of more than 5:1. Twenty-nine patients were operated on according to the previously outlined plan of colectomy and exteriorization of the remaining ends of bowel as the first stage with subsequent closure of the stoma. On two occasions one-stage ileosigmoidostomy and colectomy was performed. In a third case ileosigmoidostomy as the first stage was followed by subtotal colectomy as the second stage. In no instance was total colectomy with removal of the rectum and establishment of an artificial abdominal stoma found necessary. Approximately 30 per cent of these patients had megarectum in addition to involvement of more proximal segments but, as we have previously indicated, good results were obtained without resection of the rectum even when this portion of the bowel was involved. There were three postoperative deaths in the hospital (9 per cent). Two deaths resulted from peritonitis; the third from pneumonia.

POLYPOID DISEASE OF THE COLON

Polypoid disease of the colon is a condition in which there are several to many adenomatous polypi throughout the large intestine. Sometimes the disease is sharply limited to one segment of the colon; namely, the rectum. In those cases in which colectomy is required the entire large bowel is usually involved. The actual number of polypi in any one case in which colectomy is required may vary from a few scattered polypi ("multiple discrete polypi") to many hundreds of large and small adenomas. The latter condition, in which a major portion of the lining of the large intestine is densely studded with many polypi, is termed "diffuse polypoid disease" (fig. 398).

Diffuse polypoid disease of the colon is most often a familial disease and when one person is found to be affected it is always wise to urge examination of the other members of the family. This disease is primarily one of early life but is quite rare in preadolescent children. Those afflicted often have a tendency to frequent intestinal movements but this, being of gradual onset, does not occasion concern to the patient. Medical consultation is usually delayed until gross melena or attacks of cramping abdominal pain give cause for alarm. The results of physical examination are usually negative, except that, when digital rectal examination is performed, a soft "pebbly sensation" is imparted to the examining finger as it passes over the many small adenomatous polypi.

Proctoscopic examination is very important and should always be performed by a competent specialist in proctology. The proctologist must determine whether or not he can eradicate all of the polypi in

the rectum and rectosigmoid by fulguration. On this determination will rest the decision as to the necessity of permanent ileostomy. Accurate roentgenograms following the administration of barium and using the air insufflation technic are necessary to delimit the extent of the disease before operation (fig. 399). Roentgenography is more reliable in determining the presence of polypi in the colon than is the palpating hand of the surgeon. Small, soft mucosal polypi are notoriously difficult to feel through the intestinal wall at the time of lapar-



Fig. 338—*Polyposis coli*. The entire colon is studded with unnumerable large and small polypi. The specimen was obtained at operation on a white woman thirty nine years of age, who complained of diarrhea and occasional melena of six years duration. A preoperative roentgenogram of this same patient is depicted in figure 399.

otomy. Large, firm, easily palpable polypi have usually undergone malignant degeneration.

Surgical treatment is always indicated in cases of polyposis of the colon. The danger of delayed or expectant treatment lies in the fact that these polypi invariably undergo malignant degeneration. Too often this has already occurred when the patient is first seen. Sometimes a large infiltrating cancer is found in some segment of the colon. When such a frank malignant lesion is found in a colon which is the site of diffuse polypoid disease there will almost always be several

or many other polypi which have undergone similar but less advanced carcinomatous change. It would seem as though the polypoid disease may lie dormant and benign for many years but once malignant change takes place it affects not one polypus or one segment of the colon but many polypi in different locations at the same time. When cancerous change supervenes, the prognosis following surgical treatment is no longer that of a benign disease but that of cancer of the colon. The earlier surgical extirpation is undertaken, the less opportunity there will be for carcinomatous changes to have occurred.



Fig 399—Preoperative roentgenogram of polyposis coli using the air insufflation technic. Innumerable large and small polypi are clearly visible. The resected specimen from this same patient is shown in figure 398.

For the patient from whose rectum and rectosigmoid the proctologist can eradicate the polypi by fulguration, many different methods of colectomy have been advocated. These vary from one-stage resection and anastomosis to procedures involving four or five stages. The safest and most satisfactory procedure would seem to be a two-stage anastomosis and resection with subsequent electrocoagulation of the polypi of the rectum and rectosigmoid.

In cases of polypoid disease of the colon the mesocolon is of average or normal length. The colon is, therefore, not as easily mobilized as it is in cases of megacolon. The first stage of the operation is carried out through a lower midline or lower left rectus incision. After pri-

mary exploration of the abdomen the ileum is divided about 12 to 14 inches (30 to 36 cm) from the cecum and both ends are inverted. Isoperistaltic side to side ileorectosigmoidostomy is then accomplished using an open method of anastomosis. When the colon is opened the polypi at the immediate site of anastomosis are ligated and excised under direct vision. Often they are so numerous that ten to twelve polypi will have to be excised in this manner to obtain sufficient clear mucosa for unhampered anastomosis.

At the second stage resection of the colon is accomplished with greatest ease through a long transverse incision which is placed 1 to 2



Fig. 400—The incisions employed in subtotal colectomy for polypoid col (1) lower left rectus incision for ileosigmoidostomy at the first stage (2) long upper abdominal transverse incision for subtotal colectomy removing the colon from the cecum to the ileosigmoid junction.

inches (2.5 to 5 cm) above the umbilicus and divides both rectus muscles (fig. 400). If the patient is tall and asthenic, minor variations of this incision may provide better access to the three locations most difficult to mobilize, namely the hepatic flexure, the splenic flexure and the rectosigmoid region (fig. 401). The terminal portion of the ileum and the entire colon down to the anastomosis in the rectosigmoid area are then removed. The procedure is facilitated by removal of the mesentery, although this is not actually necessary except when a frankly malignant lesion is present. The bowel is divided immediately above the ileorectosigmoid anastomosis and the remaining end is inverted.

After the patient has recovered, proctoscopic fulguration of the remaining polypi in the rectum and rectosigmoid is undertaken. If this is done before operation it will be advisable to wait several weeks before attempting the first stage of the operative procedure. Electrocoagulation produces edema and scarring of the intestinal wall which lends itself poorly to intestinal anastomosis. To obviate this delay and avoid the increased risk of anastomosis after fulguration, the major surgical procedures are always completed first.

In those cases in which carcinoma of the rectum has already developed or the polypi are so numerous that they cannot be eradicated



Fig 401—Subtotal colectomy for polyposis coli. A variation of the incision demonstrated in figure 402. (1) lower left rectus incision for ileosigmoidostomy. (2) long oblique incision for subtotal colectomy removing the colon from the cecum to the ileosigmoid juncture.

proctoscopically, total colectomy is necessary. At the first stage a single barreled ileostoma is provided. At the second stage the entire colon down to the lower part of the sigmoid is removed through a long transverse incision (fig 402). Subsequent combined abdominoperineal resection completes the task. When total colectomy is performed in this manner it is often several weeks after the first stage (ileostomy) until the third stage (combined abdominoperineal resection) is consummated. For this reason it may be advisable to alter the procedure for those patients who already have carcinomatous

degeneration of rectal polypi. The period of waiting before the rectal malignant lesion is removed may provide sufficient time for metastasis to take place or local extension of the growth to occur. An alternate plan which obviates this is to perform as a preliminary procedure combined abdominoperineal resection with establishment of a single barreled colonic stoma. At the second stage ileostomy may be performed and in subsequent stages the remainder of the colon may be removed.

There are nineteen cases of surgically treated polypoid disease of the colon in the present series.

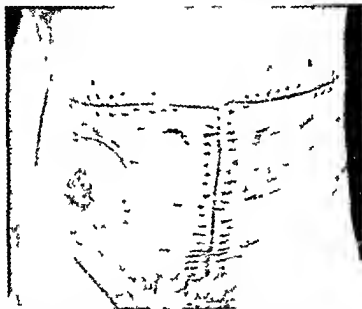


Fig. 402.—The incisions employed in total colectomy (1) muscle splitting type of incision for ileostomy (2) long transverse upper abdominal incision for subtotal colectomy removing all of the colon down to the lower sigmoid (3) lower left rectus incision for combined abdominoperineal resection.

Nine patients had a family history of polypoid disease or cancer of the colon. A higher number of patients having a familial background probably would be discovered if extensive investigation of this phase of the personal history were made but it also seems undoubtedly true that this disease does not always have familial tendencies. Diffuse polypoid disease of the colon rarely occurs in infants or children. One of us (CFD) has seen two patients each eighteen months of age. Surgical treatment was refused. Solitary polypi and multiple discrete polypi are found fairly commonly in this age group. The diffuse form of the disease, such as is depicted in figures 398 and

399, is a disease of adult life. In the present series all the patients except one had diffuse polypoid disease. The one exception was a boy, eight years of age, who had multiple discrete polypi. The condition was properly treated by subtotal colectomy. The colon from the hepatic flexure to the lower part of the sigmoid was extirpated in one stage. The resected specimen contained three widely separated large polypi.

The youngest patient—except the two mentioned previously—who had diffuse polypoid disease of the colon was twenty-one years of age. The average age of the nineteen patients was 33.5 years. Three subjects were in the sixth decade of life but none were in the seventh decade or older. Thirteen patients were male and six were female, a ratio of 2:1. All of the subjects in this series presented one or both of two predominating complaints, melena and diarrhea. One subject had had frequent loose intestinal movements, attacks of abdominal cramps and intermittent melena for thirty-four years before surgical intervention. The average duration of symptoms before surgical treatment was undertaken was 8.8 years for the entire group.

It is difficult to establish the incidence of carcinoma in the resected specimens. In most adenomatous polypi of any size changes are present which can be designated as adenocarcinoma, grade 1 (Broders' method). Some very small lesions are found to be carcinomas of higher grade. However, if we limit the incidence of carcinoma to those cases in which frankly invasive malignant lesions have spread beyond the confines of the polypus and established themselves in the intestinal wall there are five cases (26 per cent).

Seven subjects were treated by ileosigmoidostomy at the first stage, subtotal colectomy at the second stage and fulguration of the remaining polypi in the rectum and rectosigmoid at the third stage. For two others the procedure was essentially the same except for the fact that two stages were needed for subtotal colectomy. The terminal portion of the ileum and the colon around to the splenic flexure were removed first and the remainder of the left portion of the colon down to the ileosigmoid stoma was removed later. Subtotal colectomy was performed in three other cases. In two of these the disease could be entirely eradicated by removing the colon from the hepatic flexure to the lower sigmoid region. The rectum and rectosigmoid being free of disease, subsequent fulguration was not required. In one of these two cases resection and anastomosis were performed at a single operation. In the second case the ends of bowel remaining after colectomy were exteriorized and the stoma was closed later. In the remaining case of subtotal colectomy anterior resection of the sigmoid with inversion of the rectosigmoid stump and establishment of a single-barreled colonic stoma was performed at the first stage. At the second stage, ileorectosigmoidostomy was performed. At the third stage subtotal colectomy, removing the terminal portion of the ileum and the entire

colon down to and including the previously established single barreled descending colonic stoma was performed. The task was completed at the fourth stage by fulguration of the polypi in the rectum.

There were five instances of total colectomy for polypoid disease of the colon. In four cases total colectomy was successfully carried out by preliminary single barreled ileostomy, subtotal colectomy at the second stage and combined abdominoperineal resection or posterior resection at the third stage. In the remaining case of total colectomy the procedure was altered to include ileostomy at the first stage combined abdominoperineal resection with establishment of a single-barreled colonic stoma at the second stage and colectomy removing the remainder of the colon at the third stage. Two more subjects for whom total colectomy was planned succumbed after subtotal colectomy at the second stage. The variations in operative methods in these cases were occasioned by the presence of cancerous changes in the colon and rectum or inability to eradicate the polypi in the rectum and rectosigmoid by fulguration.

In the entire series of nineteen cases there were two postoperative hospital deaths (11 per cent). One patient died of generalized peritonitis. The second patient had chronic ulcerative colitis in addition to diffuse polypoid disease of the colon. The polypoid disease in this subject was not the inflammatory type of formation of polypi which is so frequently encountered in cases of chronic ulcerative colitis but generalized adenomatous polyposis. This patient succumbed from infection and peritonitis.

The results of surgical treatment of diffuse polypoid disease of the colon are good if the treatment is carried out before malignant changes have taken place. Several of the patients in this series have been followed for many years since their operation and are apparently in good health. Those patients treated by subtotal colectomy with fulguration of the remaining polypi in the rectum and rectosigmoid should be examined proctoscopically at regular intervals so that recurrent polypi will be recognized early and eliminated.

CHRONIC ULCERATIVE COLITIS

Bargen has classified ulcerative colitis into several types. Type 1 is the most frequent. It is a diffuse process which starts in the rectum and progresses proximally to involve the entire colon. This condition is usually a disease of early adult life. It is extremely difficult to treat either medically or surgically. As long as the medical treatment of this condition is as satisfactory as it is in most cases (few patients can be classified as cured by medical treatment but many can be rehabilitated to the point of being useful citizens again) the present forms of sur-

gical treatment are indicated for intractable cases. Surgical treatment involves the necessity of performing ileostomy. When good general health can be maintained without surgical treatment it is far more satisfactory for patients afflicted with the disease to have five or six bowel movements a day by rectum than a practically continuous discharge of liquid feces night and day from an ileac stoma.

Moreover it should be noted that the diversion of the fecal stream by ileostomy does not necessarily cure the disease in the colon. The patient still may have acute exacerbations and in interim periods the inflammatory process continues to smolder. We know of one instance in which the rectum and a small remaining portion of the pelvic colon were removed twenty five years after they had been completely defunctionalized following ileostomy and subtotal colectomy. On pathologic examination of the resected specimen it showed all the changes of chronic and recently active ulcerative colitis. Healing had not occurred after the rectum had been defunctionalized for twenty-five years. In many cases ileostomy has been performed for persons who had chronic ulcerative colitis. Comparatively few ileac stomas have been subsequently closed with resulting intestinal function approaching normal. In view of these opinions surgical treatment of chronic ulcerative colitis has been limited to those patients who (1) show prolonged intractability to medical treatment or (2) have complications of the disease such as perforations, strictures, a malignant lesion or repeated gross hemorrhage. Ileostomy is performed for patients who have this disease, not with the idea in mind that the stoma will be closed later but with the intent of subsequently performing colectomy. Better surgical results and a lower operative mortality rate can be obtained if surgical treatment is instituted relatively early in the course of the disease. The difficulty with this practice is that many persons will be handicapped by ileostomy who, were they given further medical treatment, might recover without operation.

Surgical operations on the colon and the terminal portion of the ileum in cases of active chronic ulcerative colitis are associated with high morbidity and mortality rates. This is occasioned by two main facts: (1) the extreme metabolic difficulties attendant on establishing an ileac stoma when the patient is already metabolically depleted and (2) the grave danger of infection. The slightest intraperitoneal manipulation of the diseased intestine may result in peritonitis. It has been demonstrated that if a retention enema of carmine red or some similar dye was given to a person who had chronic ulcerative colitis before operation, even gentle handling of the diseased bowel at laparotomy caused the particles to appear on the gloved hand of the surgeon. It is not unlikely that bacteria find their way through the diseased bowel in a similar manner during the manipulations incident to operation.

In cases of chronic ulcerative colitis the colon is contracted shortened narrowed and thick walled. The mesentery is usually thickened, inflamed and much shortened. This shortening of the mesentery increases the difficulties of mobilizing the colon in performance of colectomy. Three or more stages are often required for the total extirpation of the colon. For the first stage a small muscle splitting incision in the right lower quadrant is utilized. The peritoneal cavity is not explored. The terminal portion of the ileum is located and delivered into the incision. Oftentimes this disease involves a small segment of the terminal portion of the ileum. The bowel is carefully

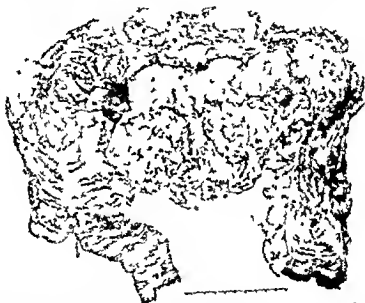


Fig. 403—Chronic ulcerative colitis type 2 showing narrowing shortening, ulceration and thickening of the bowel and intestinal wall. A segment of the right portion of the colon, the rectum and the lower part of the sigmoid were free of disease. The specimen was obtained at operation on a white man nineteen years of age who had had bloody diarrhea for four years.

inspected and a point for division is selected at least 12 inches (30 cm.) proximal to the diseased region. If this precaution is not observed the disease may subsequently spread orad above the ileal stoma and grave complications ensue. The ileum is then transected. The distal end is inverted and replaced in the peritoneal cavity. The proximal end is exteriorized as a single barreled ileac stoma. The second stage may well be performed through a long transverse incision dividing both rectus muscles. At this operation the terminal portion of the ileum, right portion of the colon, transverse colon and as much of the left portion of the colon as possible are extirpated. At

the third stage combined abdominoperineal resection concludes the total removal of the colon

In cases of chronic ulcerative colitis, type 2, of Bargen's classification the terminal portion of the colon is free of disease. The more proximal segments are, however, shortened, narrowed, thickened, inflamed and ulcerated and the mesentery is contracted, thickened and friable (fig 403). This is a segmental form of colitis which pathologically and probably etiologically is different from type 1. It is rather uncommon, less than 10 per cent of all cases being of this type. It is much more amenable to surgical treatment than type 1. When the rectum and rectosigmoid are free of disease permanent ileostomy can be avoided. Postoperative infections are less common in this form of ulcerative colitis than in type 1. With increasing experience of ulcerative colitis, type 2, we have come to believe that, if response to medical treatment is not prompt and satisfactory, surgical treatment should be instituted without delay.

Short circuiting procedures alone are of no value in this condition. Even though the diseased region may be completely circumvented, the patient often continues in ill health as long as the diseased colon remains. A more stringent reason for avoiding short circuiting operations without subsequent colectomy is the danger of spread of the disease to the region of the anastomosis. This will frequently occur unless the diseased tissue is extirpated. When it does eventuate, the anastomosis will have to be replaced at a lower level if this is possible or a permanent ileac stoma will have to be established. For these reasons colectomy is carried out as soon as practicable at the second stage after performance of ileorectosigmoidostomy at the first stage.

The usual procedure in this type of colitis is side-to-side ileorectosigmoidostomy at the first stage, the anastomosis being placed as far below the diseased region as possible. This is followed by subtotal colectomy at the second stage, all the colon being removed down to the site of anastomosis. For those patients the lower part of whose sigmoid as well as the rectum is free of disease partial colectomy can be performed as a primary procedure, the proximal end of bowel and the end of the lower sigmoid being exteriorized. The resulting double-barreled stoma can be closed later. Occasionally, one-stage resection and anastomosis will be indicated.

There are seventeen cases in which colectomy was performed for chronic ulcerative colitis. Ten were classified as type 1, seven as type 2. Nine patients were male and eight were female. The average age was 31.8 years. Bloody diarrhea was the predominating symptom. The average duration of symptoms before institution of surgical treatment in the seventeen cases was 9.5 years. Colectomy was indicated in all cases because of intractability to medical treatment. In seven cases there were additional serious complications which necessitated

surgical treatment. Four patients had obstructing colonic or rectal strictures, one a persistent fecal abdominal fistula, one intractable pyoderma and one, a superimposed colonic malignant lesion.

Total colectomy was contemplated for all of the ten persons who had ulcerative colitis type 1. Actually total extirpation of the colon was consummated in only two cases. In the remaining eight subtotal colectomy was performed, the rectum and pelvic colon remaining. Some patients died after subtotal colectomy and before the remaining segments of colon were removed. Others are living following performance of ileostomy and subtotal colectomy but have not yet had the remainder of the bowel removed. In five of the seven cases of colitis type 2, ileocolostomy was performed as the first stage of the operation and was followed by subtotal colectomy. In one, primary colectomy with exteriorization of the remaining ends was performed. The resulting double barreled stoma was closed later. In the seventh case one-stage resection and anastomosis was performed.

In the seven cases of colitis type 2, there were no postoperative deaths in the hospital and the results of surgical treatment have been, in the majority of instances, gratifying. In the ten cases of colitis type 1 there were five postoperative deaths. Four patients died of generalized peritonitis and one of bronchopneumonia.

OTHER CONDITIONS REQUIRING COLECTOMY

Multiple synchronous widely separated carcinomas of the colon may require colectomy. The following report is of such an instance.

CASE 1—A white woman fifty six years of age, underwent laparotomy for carcinoma of the sigmoid. At operation in addition to the sigmoidal lesion a large carcinoma of the cecum was found. The condition was treated by subtotal colectomy. One stage resection of a portion of the terminal segment of the ileum and the colon with its attached mesentery from the cecum to the rectosigmoid junction was performed. Intestinal continuity was regained by side-to-side ileorectosigmoidostomy. The patient made a satisfactory recovery. Pathologically the cecal lesion was an adenocarcinoma grade 3 (Broders) type B (Dukes). The sigmoidal lesion was a polypoid adenocarcinoma grade 1 (Broders) type A (Dukes) (fig. 404).

Multiple asynchronous surgically treated colonic malignant lesions will often also eventuate in extirpation of long segments of the colon. One patient on whom we recently operated had had three separate asynchronous colonic carcinomas. Right hemicolectomy had been performed thirteen years previously, resection of the descending colon eight years previously and at the last operation resection of the entire sigmoid and rectosigmoid. All that remained of the colon following the last procedure was a portion of the transverse colon, the splenic flexure and the rectal stump. In this review no attempt has been made to collect all cases in which colectomy was performed for cancer.



Fig 404—Subtotal colectomy for multiple synchronous carcinomas of the colon. The cecal lesion is an adenocarcinoma grade 3 (Broders) type B (Dukes). The sigmoidal lesion is a polypoid adenocarcinoma grade 1 (Broders) type A (Dukes). The specimen was obtained at operation on a white woman fifty six years of age.

The following case of *diverticulosis and diverticulitis of the colon* indicates how colectomy may be occasionally necessary in this condition.

CASE 2—A white man fifty six years of age presented extremely extensive diverticulosis extending from the hepatic flexure to the lower part of the sigmoid. The entire sigmoid colon was involved by perforated diverticulitis. The patient stated that he had undergone low midline transverse colostomy. At the first operation at the Clinic the transverse colonic stoma was relocated in the upper mid line and the sigmoid colon was resected. The proximal end of the descending colon was inverted. The ileum was transected and side-to-side ileorectosigmoidostomy was performed. At a later date to rid the patient of the remaining diverticula and the transverse colostomy which existed as a mucous fistula the colon from the cecum to the inverted end of the descending colon was removed.

The next case illustrates how colectomy may be the method of choice in eliminating *multiple fecal abdominal fistulas*.

CASE 3—A white woman forty seven years of age stated that she had been operated on for diverticulitis of the sigmoid several years prior to admission and that several subsequent operations had been performed for recurrent intestinal obstruction and fecal abdominal fistulas. When first seen she presented a fecal fistula in the right lower quadrant which arose from the cecum. There were two

transverse colonic stomas and three widely separated fistulous openings arising from the left side of the colon. At the first stage of the operation ileosigmoidostomy was performed. The colon from the cecum to the point of ileosigmoid anastomosis and all of the fecal fistulas and colonic stomas were subsequently removed in two stages.

Occasionally colectomy is performed to extirpate a long segment of defunctionalized colon, one segment of which has been exteriorized and exists as a mucous fistula. The following case is illustrative.

CASE 4.—A white man, forty-one years of age, stated that he had undergone partial right colectomy and ileotransverse colostomy in 1915 and that shortly thereafter ileosigmoidostomy had been performed because of obstruction at the site of the former anastomosis. When the patient was first seen at the Clinic in 1923 the ileosigmoid stoma had contracted and was causing chronic obstruction. The portion of sigmoid colon proximal to the ileosigmoid anastomosis was transected, a new ileosigmoidostomy was performed at the end of the upper part of the sigmoid colon. Thirteen years later the patient returned with obstruction at the site of the mucous fistula. This was accomplished by removing all the remaining colon proximal to the exteriorized end of the upper part of the sigmoid.

SUMMARY

This report is based on seventy-two consecutive cases of total or subtotal colectomy. In thirty-two cases the operation was performed for megacolon, in nineteen for polypoid disease of the colon, in seventeen for chronic ulcerative colitis and in four for miscellaneous conditions.

In cases of megacolon the mesentery of the colon is elongated; in cases of polypoid disease it is of average or normal length and in cases of chronic ulcerative colitis it is shortened and thickened.

Megacolon is often best treated by primary partial colectomy, exteriorizing the remaining ends of bowel and subsequent closure of the colonic stoma. It is not necessary to remove the rectum and rectosigmoid in cases of megacolon involving these segments. Resection of the more proximal diseased segments and defunctionalization of the rectum and rectosigmoid followed by late closure of the colonic stoma provide good results.

In many cases of polypoid disease of the colon the best procedure is ileorectosigmoidostomy at the first stage, subtotal colectomy at the second stage and fulguration of the remaining polypi in the rectum and rectosigmoid at the third stage. For those persons who have polypi in the rectum and rectosigmoid so numerous that the proctologist cannot eliminate them by electrocoagulation methods and for those who have cancerous degeneration of rectal polypi, total colectomy with establishment of a permanent single barreled ileac stoma is necessary.

Surgical treatment is provided for only those persons having ulcer

tive colitis, type 1, who show prolonged intractability to medical treatment or who have severe complications of the disease. In cases of ulcerative colitis, type 1 in which surgical treatment is indicated, preliminary ileostomy is followed by subsequent total colectomy when ever possible. In cases of ulcerative colitis, type 2, ileorectosigmoidostomy at the first stage is followed as soon as possible by subtotal colectomy at the second stage.

The postoperative (hospital) mortality rate after colectomy for megacolon was 9 per cent and for polypoid disease 11 per cent. For intractable ulcerative colitis (types 1 and 2) there were five deaths in seventeen cases (29 per cent). None of these deaths occurred in cases of ulcerative colitis type 2.

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REMARKS CONCERNING MALIGNANT LESIONS, POLYPOID DISEASE AND DIVERTICULA OF THE TERMINAL PORTION OF THE LARGE INTESTINE

LOUIS A. BUIE

MALIGNANT LESIONS

THE physician in general practice is responsible for the early diagnosis of lesions of the terminal portion of the large intestine. A patient whose symptoms are referable to the large intestine does not often consult a specialist early in his illness. Many patients will use home remedies first. Physicians however are more alert to problems of this kind than ever before and probably they detect the lesions more often now than formerly.

"Rectal trouble" is the complaint of many patients who have carcinoma of the terminal segment of the large intestine. Far too many of them have been treated for some other supposed rectal condition and the carcinoma has remained undiscovered. As soon as a person notices any peculiarity of function of the large intestine he should consult his physician. Most persons however, procrastinate. Therefore when the patient has summoned sufficient courage to seek consultation the physician's examination should be thorough. From an educational standpoint he should encourage those afflicted with rectal disorders to present themselves for examination early and he should convince them of the needlessness and danger of false modesty. Only in this manner will it be possible to shorten the period of uncertainty which may be tragically costly.

Age and Sex—Of those who have malignant lesions of the large intestine the average age is approximately fifty five years. Almost 90 per cent of the patients are more than forty years of age but a small percentage are less than twenty years old and occasionally children less than ten years of age are afflicted. Sixty five per cent of the patients are men.

Pathology—Approximately 95 per cent of the lesions are adenocarcinomas. Sixty five per cent are 6 cm. in diameter or larger and approximately 65 per cent possess some degree of immobility or are fixed entirely. Only 1 per cent of the growths that I have seen were lesions of grade 4 (Broders method). 15 per cent were of grade 3, 39 per cent of grade 2 and 45 per cent of grade 1.

The usual classifications of carcinoma of the large intestine papillary, fibrous, medullary, mucoid or scirrhous designate different peculiarities which may be found in the adenoid form of carcinoma. Less com-

fusion results if they are all included in the general term of "adenocarcinoma"

Lymphatic Involvement—Examination of the lymph nodes should indicate the presence or absence of metastasis and all relevant nodes should be examined. Sometimes no evidence of distant metastasis will be found near the primary growth. The lesion may have metastasized to the liver even though the nodes between the primary growth and the liver are unaffected. Often, on microscopic examination evidence of malignancy will be found in a node which grossly appears normal, on the other hand, a node which seems to be involved may prove to be the site of inflammatory change only.

Situation of the Growth.—Between 90 and 95 per cent of the lesions which can be seen on proctoscopic examination involve the rectum, rectosigmoid or sigmoid and only 5 to 10 per cent involve the anus. Not all tumors that involve the anus are primary in the anal canal, some extend down from the wall of the rectum and involve the anus secondarily. Approximately 35 per cent of malignant neoplasms in the terminal portion of the large intestine involve the anus and lower half of the rectum, 60 per cent involve the upper half and about 5 per cent involve that portion of the sigmoid which can be viewed through the proctoscope. The surgeon who performs the operation finds it advantageous to determine the site of the growth as nearly as possible preoperatively. In almost 60 per cent of the cases, the examiner will find evidence of some degree of obstruction, but this difficulty appears as an emergency problem in only 1 to 2 per cent of cases.

Symptoms.—Malignant lesions of the terminal part of the large intestine may give rise to a wide variety of subjective and objective manifestations which may be modified by many factors. In the early stages small lesions may not influence physiologic function. Early carcinoma of the rectum may not give rise to symptoms. When the disease is extensive, symptoms and signs may develop which are not only characteristic of malignancy but also of many other diseases of the large intestine. The chief complaint is of bleeding in 85 per cent of the cases. Some patients relate that the passed blood is light, others that it is dark, some say that it is passed as clots, and a question as to whether it is mixed or unmixed with the fecal matter may elicit a positive response either way. All of this proves that not much dependence, from the standpoint of diagnosis, can be placed on the patient's account of his symptoms in the presence of disorders of the large intestine. If the patient has passed blood or has noticed anything else unusual relative to his intestine or anus or their function, the physician must assume that a malignant lesion is present until he can prove that no such lesion exists. Malignant disease of the terminal portion of the large intestine could be discovered earlier and hence

could be treated more successfully if discomfort were present from the beginning. Patients who will endure mere irregularities produced by disease will hasten to a physician when pain becomes manifest.

Pain as the result of rectal carcinoma often appears late and the definite discomfort high in the intestine usually is caused by obstruction due to the annular type of lesion. Occasionally, when the lesion involves the sensitive margins of the anus severe pain may occur early in the course of the disease. However, usually the discomfort is not a definite pain but rather a feeling that evacuation has been incomplete because the lesions involve that part of the intestine in which no sensory innervation is present. The intestine above the lesion may become distended and hyperactive only late in the disease and, consequently, abdominal discomfort may never be experienced in the early period, in fact, it may be considered to be evidence of advanced development. An indefinite, aching type of pain usually is owing to invasion of the pelvic structures by the malignant process, and often urinary disturbances are associated with it.

Diagnosis — Digital Examination — The presence of a malignant lesion, its position and the degree of mobility can be determined by digital examination. Such examination makes it possible to perform intelligently the subsequent proctoscopy. If care is taken pain will not occur unless a painful lesion is present at the outlet and then a swab saturated with solution of cocaine, or regional anesthesia should be used. If the ulcerated base and margins have been mangled by the digital examination proctoscopic examination may be impossible. Blood then fills the rectum and in spite of all efforts to clear it away the continual oozing from the broken surface of the growth obscures the field.

Proctoscopic Examination — Fully 75 per cent of malignant lesions which involve the large intestine occur in that portion which can be examined with a proctoscope. The progress of the proctoscope must be stopped as soon as it enters the rectum when the presence of a malignant lesion in the rectum is suspected. As soon as the lower part of the rectum has been entered the obturator must be removed and every move of the instrument must be watched carefully as it is pushed gently into the large intestine.

The characteristic finding if a carcinoma is present is a single lesion on an otherwise uninvolved intestinal wall. It may be a proliferative mass projecting from one wall and the remaining walls may be visible. If the lesion is situated in the intestine where the lumen is smaller a proliferative mass blocking the lumen is more likely to be found. The intestine may appear to be a tube of necrotic tissue with marginal fringes which are polypoid or edematous or a necrotic, crateriform ulcerative lesion with piled up polypoid margins may be observed. The characteristics of malignancy are found not only in the appear

ance of the lesion but also of the margins of the growth where a definite line of demarcation can be observed between the lesion and the tissue which it involves.

POLYPOID DISEASE OF THE LARGE INTESTINE

Polyps are growths which may be pedunculated or may have no pedicle and they may occur singly or in numbers. In most instances adenomatous features are apparent but polyps may have fibromatous, papillomatous and other histologic characteristics.

In this discussion when multiple polyps are present, the condition will be described as "multiple polypoid disease" and a qualifying phrase will be used to describe the situation and extent of the process. Thus, the condition will be termed as multiple polypoid disease of the sigmoid when only the sigmoid is involved.

"Multiple polyposis" has been the term used for the condition in which the entire large intestine is involved, but I shall employ the expression, "multiple polypoid disease of the large intestine." Two forms of this disease may be observed grossly and both may be manifest in different portions of the same large intestine. In one, discrete polypoid outgrowths in which the sessile types predominate are found on the intestinal wall but no gross evidence of pathologic development is found in the tissues which intervene. In the other, a diffuse, hyperplastic involvement occurs in which many polyps of all types, sizes and shapes are found as the predominant feature. For the first form the term "multiple polypoid disease of the large intestine" will be used but for the second, "multiple polypoid disease of the large intestine with diffuse hyperplasia" will be used.

Etiology.—It is possible that the question as to whether polypoid disease of the large intestine develops after birth or as part of some hereditary, familial or protoplasmic peculiarity may be answered eventually. The problem is similar to the one which deals with the cause of pathologic proliferation of tissue and therefore at present is still unsolved.

Polypoid disease is considered by some to be either congenital, by which they imply that the disease is due to some inherent factor which has developed prior to birth, or acquired after birth. That polypoid disease often is the result of some peculiar cellular tendency or arrangement which probably antedates birth is generally assumed. However, there is plausible support for the belief that occasionally these tumors develop as a result of reparative effort as the body defends itself against the onslaught of infection and irritation, such as those which attend chronic ulcerative colitis. The fact that a heredo-familial history is so often given by those who are afflicted with multiple polypoid disease of the entire large intestine, supports the hypothesis that a constitutional factor may be concerned. Often, patients

have given a history sufficiently lucid to serve as indisputable proof that similar conditions have existed among relatives and forebears McKenney stated that the condition is observed in babies and small children and that members of several generations of the same family may have the disease Usually, only those cases in which the entire large intestine is involved by polypoid disease fit into the heredo-familial classification and the commonly accepted designation for this form of the disease has been "multiple polyposis"

Incidence.—The incidence of polypoid disease of the large intestine cannot be calculated by any reliable method The total number of cases probably would reach unexpected proportions if exhaustive investigation could be made among the relatives, forebears and descendants of all patients who have been found to have the disease A statistical report of only those cases which have come to the attention of one physician or of those working in a single institution is of doubtful value It is of only academic interest that in a ten year period at the Mayo Clinic approximately one of every thirty five patients who complained of disturbed function of the large intestine had polypoid disease

Cases in which one or only a few polyps were found comprised the largest group About 60 per cent of the patients were men and 40 per cent were women The average age of patients was about fifty years 8 per cent were less than thirty, and only about 2 per cent were less than twenty years of age In a smaller group, composed of cases in which multiple polyps and inflammatory disease of the large intestine occurred together the average age was thirty eight years and about 30 per cent were less than thirty years of age In a still smaller group of cases of multiple polypoid disease of the entire large intestine the average age of the patients was thirty seven and 42 per cent were less than thirty years of age, 11 per cent were less than twenty Similar sex distribution was noted in the three groups

Pathology—Sessile Polyps—In routine proctoscopic examinations probably half the polyps seen are small sessile growths and some disturbance of function of the large intestine, which bears no relation to the polyps is the chief complaint These polyps are adenomatous in structure and the diameter is usually from 5 mm. to 1 cm. Although single polyps do occur, diligent search always should be made for others They may grow out into the lumen of the intestine without developing a pedicle and may grow to enormous size

Diffuse Polyps—A polypoid condition which leaves no normal areas within the segment which is diseased involves the mucous membrane in this disease The character of the wall of the intestine itself is one of the most distinguishing features The polypoid disease occurs in conjunction with, and as a part of, diffuse hyperplasia of the mucous membrane Pedunculated polyps may be associated with this condi-

tion Tissue which bears the characteristics of malignancy of low grade will be found sometimes in a mass of polypoid outgrowth. A great quantity of mucus is secreted by such lesions and is excreted by the patient. Many times expulsion cannot be delayed.

Pedunculated Polyps—These polyps may occur as single tumors or in scattered collections. If they appear in great numbers hereditary familial disease is usually present. These tufts of polypoid tissue are attached to the wall of the intestine by stems of mucosa and muscularis which project into the lumen. The polyp may be only a few millimeters in diameter or it may fill the lumen of the intestine. The length of the pedicle varies widely.

Symptoms and Signs—Polyps may exist singly or in large numbers within the large intestine for many years and may produce no physical evidence of their presence. More often single polyps are discovered by "accident" than because the patient has had symptoms referable to the polyp. It is sometimes especially difficult to persuade a patient that a single tumor should be removed when the lesion bears no relation to his major complaint. In approximately a third of the cases blood has been observed in the stool and probably the polyp was the source half the time. Single polyps discovered in this casual manner are less than a centimeter in diameter in about 80 per cent of cases.

Rarely such a lesion will be discovered for the first time when an extensive hemorrhage occurs. This usually happens when a portion, or even all of the polypoid mass is torn away from its mooring or its sessile base by the effect of peristalsis or of pressure of the intestinal content.

Symptoms will not be produced by a single growth unless it is of sufficient size or occupies such a position as to cause disturbance of function. Discomfort may result from hyperactivity of a segment of intestine when a large tumor is situated in the lower portion of the sigmoid or rectum. Abdominal cramps, tenseness, gas and frequent unsatisfactory attempts to empty the rectum may be manifest and blood and mucus may be passed. Obstruction may supervene in the few cases in which the tumors are very large. In still fewer cases the pressure on the polypoid mass as the intestinal action and current force it distally may draw a segment of intestine into the lumen of an adjacent portion and thereby produce intussusception.

Some patients who have multiple polyps may have no symptoms at all while others may be totally helpless because the large intestine is completely involved with diffuse hyperplastic polypoidosis, slough, ulceration and malignant invasion.

The more disease that there is in the sigmoid and the rectum and the nearer the disease is to the rectal outlet, the more intense will be the physical disturbance. It is usually considered that the severity of physical disability increases in direct proportion with the involvement

of the large intestine. However, the amount of pathologic involvement of the rectum and sigmoid is a more significant factor in the disturbance of intestinal function.

Vague abdominal discomfort and increased desire to evacuate the bowel are usually the first symptoms in the heredofamilial type of the disease. These symptoms may pass practically unnoticed but when blood begins to appear in the stools the patient often seeks consultation. In the later stages it is discouraging to see these patients who are hopeless physical remnants as the result of constant bloody mucous purulent discharges from the bowel abdominal rectal and anal distress and loss of morale sleep appetite and weight. Such patients may be sick for years.

Diagnosis—In some cases careful proctoscopic examination of the interior of the large intestine may offer the only possibility of finding some small polypoid lesions, because sometimes they cannot be felt on digital examination and often they are too small to be detected by roentgenologic examination. On proctoscopic examination polyps may appear as single minute excrescences scarcely 1 mm in diameter. They should not be ignored because many have been removed and have been found to be of adenomatous structure.

The polyp is usually sessile or pedunculated and 5 mm to 1 cm in diameter. If the polyp is sessile it is usually of the same color as the mucous membrane. If it is pedunculated the pedicle is of the same color as the mucous membrane but the polyp itself is often a darker red. The color is altered when it sloughs or becomes ulcerated.

The diagnosis is easy if the involvement is extensive because the growths can be felt on digital examination and the recesses of the large intestine have a typical appearance when viewed through the proctoscope.

Treatment—Complete eradication of the area involved by the disease or complete destruction of the lesion itself as well as of the adjacent tissues when the wall of the intestine is included in the pathologic process should be the objectives of treatment. A solitary lesion in a portion of the intestine which can be reached through the proctoscope may be destroyed by fulguration. Laparotomy and excision of the tumor with or without excision of a portion of the intestine depending on the morphologic and histologic structure of the lesion should be performed when the lesion is not accessible to the proctoscope.

Fulguration—Most polypoid lesions are found in that region which can be explored by the proctoscope and if a few precautions are taken they may be destroyed by fulguration. Several features are of significance in the technic of fulguration. 1. The patient must cooperate during the procedure and therefore general anesthesia should not be employed. Even if small lesions occur in great numbers they often can

be fulgurated without anesthesia 2 To facilitate visualization of the proximal recesses of the terminal portion of the large intestine the patient should be placed in the inverted position 3 Fulguration of small lesions, especially if pedunculated, may be performed in the office Less care is necessary if the lesion is situated below the peritoneal reflection than if it is in the mobile portion of the rectum or sigmoid 4 In cases in which small rectal lesions have been fulgurated, the patients may remain ambulant, but they should be hospitalized and observed more closely if the lesion is large, or even if a small lesion is in the mobile portion of the intestine During the first few days after fulguration the danger of hemorrhage is not so great, but from the fifth to the tenth day, when the slough comes away, the danger is increased Perforation may occur and this possibility is a further indication for hospitalization 5 Small doses of radium can be applied topically in order to provide additional insurance against hemorrhage 6 The length of the period during which patients should be observed following fulguration varies within broad limits and can best be determined by careful re examinations Fulguration may have to be carried out fractionally over a period of several months when diffuse polyposis is present and all the walls of a segment are involved If a lesion 3 to 4 cm in diameter is destroyed by one application, the patient may be kept under close observation for three or four weeks, dismissed and may return for examination several months later Occasionally when it is necessary to destroy polyps which involve the entire rectum and a portion of the sigmoid it may be necessary to carry on treatment and observation for a much longer period

Technic of Fulguration—The amount of monopolar current required for fulguration can best be determined by personal experience By placing the tip of the electrode directly against the surface of the tumor it can be destroyed completely When the tip of the applicator is being removed from the lesion care should be taken that the entire lesion does not break away from the wall of the intestine because a blood vessel may be opened The flow of blood would temporarily interfere with completion of the treatment Therefore, the tip of the applicator should not be brought directly in contact with the lesion The same amount of destruction can be accomplished without the inconvenience of bleeding if the applicator can be held so that the spark will leap about 6 to 8 mm from the electrode to the surface of the growth

Treatment of multiple polypoid disease which complicates inflammatory disease of the large intestine should be considered separately from that which is hereditary

When multiple polypoid disease occurs secondary to chronic ulcerative colitis or other inflammatory disorders, the primary condition usually demands attention Polyps which can be reached through the

proctoscope can be destroyed by fulguration but nothing else can be accomplished by this method

In treatment of the heredofamilial disease in which the polyps are discrete and the wall of the intestine between them is relatively uninvolved the polyps which can be reached with a proctoscope can be fulgurated and the polyp bearing portion of the intestine can be removed After partial colectomy ileosigmoidostomy may be performed and thereby normal exit and function of the remaining portion of intestine can be retained However in the type in which hyperplasia of the mucous membrane is diffuse and polyps are present total colectomy must be performed

DIVERTICULA

Diverticula of the terminal portion of the large intestine are blind tubes or sacs branching from the walls of the intestine and they have been classified as true or "false" All the coats of the intestinal wall are included in true diverticula those which are false are composed of only mucous membrane which has pierced through the muscular layers and has projected beneath the serosal surface which serves as the second covering Just why they should be considered false is not clear because neither thinness of their walls nor the fact that they are thought to be acquired would seem to exclude them from among the true diverticula

Diverticuli have been classified also as congenital or acquired The anatomic anomalies which form during the prenatal period of development are called "congenital diverticula" Those which appear in postnatal life because of developmental difficulties or because of some weakness which exists in certain portions of the intestine are considered to be acquired for example in cases in which the mesentery fails to cover the intestine and in which blood vessels pierce the wall the diverticula are classified as acquired Usually congenital diverticula are assumed to have four coats and acquired diverticula to have only two It seems possible however that these numbers might be reversed

A Suggested Classification—The terminology suggested herein will possess little value if the terminology heretofore in common use is retained The classification which I suggest is as follows

Prenatal Diverticula—Two types of diverticula develop in utero (1) those which form as true anomalies and all walls of the intestine are included in the walls of the sacs and (2) those which are hernias of the mucous membrane between the developing structures of the intestinal wall They lie beneath the serosa and their walls consist of mucous membrane and serosa

Postnatal Diverticula—Separation of types depends not on the structure of the diverticula but on the time of their formation These diverticula form after birth

Postnatal diverticula into two types depending on why and when they form and on whether the mucous membrane herniates

ates through, or between, muscular structures of the intestinal wall. They lie beneath the serosa and their walls, accordingly, consist of mucous membrane and serosa.

Postnatal diverticula of the first type form because the wall of the intestine is weak between imperfectly encircling muscular structures; pressure and other physiologic processes within the large intestine are normal. These diverticula appear in adolescence.

Postnatal diverticula of the second type form because pressure and other physiologic processes within the intestine are sufficiently abnormal to force the mucous membrane through, or between, what would be presumed to be adequately encircling muscular structures. These diverticula appear in adult life, usually not until the fifth decade.

Etiology.—The causes which are responsible for the development of the second type of postnatal diverticula need further elucidation. The large intestine is nourished by blood vessels which pierce its walls and certain parts are weak where the mesentery is attached. With the changes which occur with advanced age diverticula may develop at these weak points. The increased pressure of gas which normally forms within the large intestine or the strain of undue physical effort may cause no irregularity early in life; but, later, diverticula may develop when the intestine becomes more susceptible to these influences. Therefore, these anatomic irregularities may occur not only as a result of unusual strain but also because of the effect of normal processes on tissues which, with advancing age, have developed abnormal characteristics.

Incidence.—Until diverticula become the site of another pathologic process no indication of their presence is given. Although the exact incidence cannot be determined, it is likely that the secondary pathologic development occurs with extreme rarity in comparison with those instances in which dormant diverticula exist. Probably many intestinal diverticula are never discovered. In authoritative reports, the occurrence of evidence of diverticula in roentgenograms has varied from 1.24 per cent to 10 per cent. Weber reviewed the records of more than 50,000 patients on whom roentgenologic examinations of the large intestine have been made at the Clinic. Diverticula were found in more than 3,000 cases, an incidence of 5.9 per cent. These figures have no value in determination of the incidence of diverticula except among patients who consult physicians.

Determination of the incidence of diverticulitis is also difficult. Of one group of 1,549 patients with diverticula of the sigmoid, about half complained at some time of symptoms which could be attributed to inflammation or other active processes; 181 (11.6 per cent) required surgical treatment. Weber stated that evidence of diverticulitis was present in 15 to 20 per cent of cases in which diverticula were found at roentgenologic examination of the colon. At the Clinic we have

found that in some cases evidence of clinical diverticulitis may be present but roentgenologic changes are not manifest. The number of such cases is not known because in many instances in which a clinical diagnosis of diverticulitis is made proof of the existence of the condition is lacking.

Age and Sex—About 94 per cent of patients harboring diverticula are more than forty years of age. In no case have we found diverticula in children less than ten years of age. The average age is about fifty-seven years and the ratio of males to females is about 3:2.

Anatomic Situation—The left half of the large intestine is the most common site of diverticula. They seldom are found elsewhere than in the sigmoid or immediately adjacent to it. The reasons for this apparently are (1) that in the lower part of the sigmoid and upper part of the rectum a serosal coat frequently is absent and (2) that patients who have diverticula often are constipated. The rectum of a constipated person usually is full. Therefore a great part of the brunt of muscular hyperactivity as well as that of accumulated gas is exerted in the segment which is immediately above the blocked outlet and it is in that segment that the blowout is most likely to occur.

Pathology—A diverticulum consists of a constricted neck about 1 to 3 mm. in diameter at the point where it traverses the wall of the intestine and a dilated pouch about 4 to 8 mm. in diameter which expands after the sac has passed beyond the wall of the intestine. The size of the aperture as well as the cavity of the pouch may vary somewhat and in some cases these limits may be greatly exceeded.

The pathologic processes which attack diverticula are either inflammation or malignancy. Inflammation may develop when feces seeds or other foreign particles accumulate in the diverticular sac. Also inflammation of the diverticulum may result from spread of inflammation of the mucous membrane. Disintegration and ultimately ulcerous transformation may develop when the mucosal lining of the diverticulum becomes involved. Inflammatory and hyperplastic changes may ensue and become so extensive that a mass becomes palpable through the abdominal wall. If perforation occurs abscesses encapsulated within the substance of the inflammatory mass may form. In some cases the diverticulum may adhere to other segments of the intestine, the bladder or other adjacent viscera and if it breaks through a fistula may be formed. Although it was once thought that carcinoma frequently occurred in the sigmoid in cases in which diverticula were present that complication is now thought to be rare. However the possibility that carcinoma exists in cases of diverticulitis should be considered until it is proved to be absent even though this coexistence is rare.

Symptoms—The most constant single evidence of pathologic involvement of diverticula is abdominal discomfort usually most prom-

ment in the left lower portion. Pain may be acute or intermittent and piercing or a dull, boring discomfort may be present almost constantly. In acute attacks abdominal rigidity, nausea and vomiting may occur, and the abdomen may be tender following the attack. An obstructive phase occasionally assumes the proportions of an emergency and a distinct mass may be palpable in these cases. The masses which are attributable to diverticulitis may recede, at least partially, following the acute phase.

Vesical symptoms may be manifest and these irregularities may be caused by adhesions between a diverticulum and the wall of the bladder or by actual perforation and formation of a fistula.

Diagnosis.—*Roentgenologic Examination*—Roentgenology provides the most valuable single aid in establishing the diagnosis of diverticulitis and it is almost the only means whereby undiseased diverticula can be discovered. The outline of the large intestine after a barium enema is observed roentgenologically and by this method the diverticula are seen as rounded, pouchlike shadows along the contour of the intestine. Also, hypermotility may be observed when inflammatory disease irritates the involved segment. Possibly only sharp, serrated haustra will be observed, the involved segment of the bowel may present a somewhat narrowed lumen, or extreme occlusion may be observed. These deformities may appear as false filling defects, owing to spastic narrowing which may become extreme enough to approach complete occlusion or as actual filling deformities produced by infringement on the lumen of the intestine by formative inflammatory developments around its circumference. In the inflammatory disease, the involved segment is likely to be long and the contours concentric, whereas in malignant disease, the outlines are sharply irregular and the involved segment is shorter.

Proctoscopic Examination—Four signs may be identified on proctoscopic examination which either establish the presence of a diverticulum in the terminal segment of the large intestine or provide evidence that the condition exists: (1) relative immobility in a segment which is normally freely movable, (2) angulation of the lumen, (3) reduction of the lumen and mucosal folds due to some influence which squeezes the wall and produces mucosal folds and (4) sigmoidal saccululation. This last peculiarity usually is observed in a mobile sigmoid which gives no evidence of perisigmoidal inflammatory disease. The sacculations appear as shallow pouches which may extend partially or entirely around the wall and they are separated by diaphragmatic or ridgelike elevations across the lumen of the sigmoid. The sac can be distinguished from spastic contracture because it fails to disappear.

It is rarely possible to see the diverticula in a case of active diverticulitis. They are seen most frequently when no inflammatory disease is present.

Treatment.—A conservative attitude should be taken when acute symptoms appear. Sigmoidal diverticula do not swing free into the

occurs periodically the sacs become enmeshed in a hyperplastic mass, and hence the possibility of extension of the process to the abdominal cavity is reduced and formation of localized abscess is more likely. Probably only about a fourth of the patients who have diverticulitis should be treated surgically.

Indications for operation are acute perforation, abscess, fistula (external, vesical, intestinal or multiple), inflammatory obstruction and malignancy. When none of these complications arise, conservative

abdomen. When acute symptoms begin to subside, a bland anticonstipation diet can be substituted. If any obstructive difficulties occur mineral oil in small quantities should be given. A patient should be impressed with the seriousness of his condition and even when no emergency exists, he should care for himself under the guidance of a physician.

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PROCTOLOGIC DIAGNOSIS

NEWTON D. SMITH

Prompt diagnosis of lesions in the lower portion of the large intestine and the anus often is lifesaving. Early diagnosis of an obscure pathologic process, involving the anus, rectum, sigmoid or any adjacent tissue must also stimulate the confidence of any practitioner of medicine, surgery or any of the associated specialties. The proctologist usually feels the need for continued explanation of the methods and the importance of prompt diagnosis of lesions and abnormalities which occur in the anatomic parts mentioned.

In the practice of medicine, too frequently, in spite of all that has been said, hemorrhoidectomy is performed or hemorrhoids are treated while in the rectum only a few centimeters above the anus, carcinoma is present. The fact that hemorrhoidectomy sometimes is performed in the presence of chronic ulcerative colitis re-emphasizes the need for continued comment concerning diagnosis of diseases and abnormalities occurring in the anus, rectum, or sigmoid. When tardy examination of a patient who has been treated for months for mucous colitis reveals that within the reach of the examining finger is a large annular carcinoma, it would seem that the importance of accurate proctologic diagnosis should be stressed with renewed vigor.

The fundamentals of proctologic diagnosis are those involved in most diagnostic procedures: (1) inquiry to determine the patient's complaint and the proper evaluation of his replies, (2) preparation for inspection, palpation and proctoscopic examination, (3) inspection of the exposable portions, gluteal surfaces, sacrococcygeal, perianal and perineal regions, and that portion of the anal canal which can be easily everted, (4) palpation of the same parts and gentle examination of the anus and lower part of the rectum and adjacent tissues digitally and, if the need is determined, bidigitally, (5) visualization of the lower 24 cm. of the large intestine proctoscopically and (6) solicitation of the aid of the roentgenologist, pathologist and clinical pathologist when they can assist in making the diagnosis.

These fundamentals are simple—so simple that negligence in applying them seems unjustified even when the slightest indication is observed. When they are applied the reward is realized so promptly that the physician must feel encouraged to continue their employment. It is interesting also that negative information often is of as much importance and assistance as are positive findings. This is illustrated in cases in which patients are treated for chronic ulcerative colitis when they do not have this disease. Error could be avoided easily if examination had been accomplished in the manner suggested.

INQUIRY CONCERNING COMPLAINTS

Asking the patient questions concerning his condition must be done with alertness and care because the patient frequently will have decided on his own story and the facts tend to become obscured. Do you have pain? Where is it? Is it associated with bowel movement? How long have you had it? Is it becoming more severe? This type of question usually elicits specific information that longer questions fail to disclose. It is well also to use words which the patient can understand readily often they will understand "boil" much more readily than "abscess." Questions such as the following will elicit specific information. Do you take anything to make your bowels move? "Do your bowels move each day?" While a question such as "Are you constipated?" requests the patient's opinion. These examples briefly indicate some of the care to be exercised in gathering accurate information. The information gained should assist the physician but it must not hinder him from carrying out all of the other steps in arriving at the diagnosis.

PREPARATION FOR INSPECTION, PALPATION AND PROCTOSCOPIC EXAMINATION

The need to prepare patients with enemas and also the sort of enema to be employed have given rise to much discussion. Many patients can be examined without special preparations and some physicians therefore attempt to examine all patients without preparation. If examination without preparation proves unsatisfactory then the patient is requested to take enemas until the returning fluid is clear. Such an arrangement seems satisfactory but if a large number of patients are to be examined it seems advantageous to have all patients prepare themselves before coming for examination. A solution of soap-suds is satisfactory to cleanse the large intestine and does not seem to irritate the intestine enough to contraindicate its employment even in the presence of ulceration.

To drape the patient for examination a small square sheet and a 4 by 8 inch (10 by 20 cm) gauze sponge are sufficient but a hand towel is often useful. The sheet should not be draped around the patient like a skirt but should cover him. After the sheet has been draped so that the part to be examined is exposed the upper corners can be tucked under the patient above the waist or they can be overlapped in the midline above the level of the sacrum. When the knee-chest position is used it may be necessary to pin the sheet to keep it in place. The gauze sponge then may be placed over the perineum.

One of three positions for the patient usually is employed for proctologic examination the inverted position, knee chest position or left lateral position. Some physicians employ one to the exclusion of the

other two but it is advantageous to be able to employ any one of them as the occasion permits or requires.

A special table is required for examination of a patient in the inverted position. Buie has designed the most satisfactory one (fig. 405). It provides stability, maximal comfort for the patient and the physician during examination and permits adjustment for patients of vari-

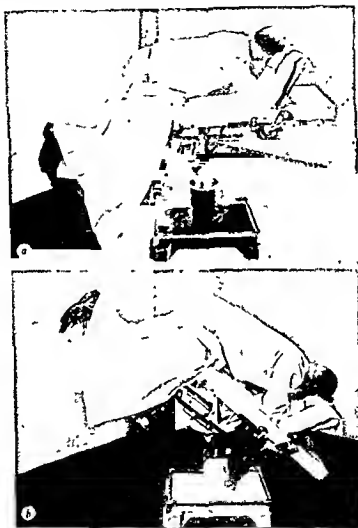


Fig. 405.—*a*, Patient before being tilted, *b*, patient tilted and draped for examination.

ous proportions or for those who require alteration of weight bearing while they are in the inverted position.

Those physicians who do not have such a table or do not feel the need for it, may place the patient in the knee-chest position or knee-shoulder position (fig. 406). Either of these positions will provide satisfactory exposure but will be less comfortable than the inverted

position No pillow is used for the patient to rest his head on The right arm of the patient is pulled diagonally across his thorax so that the hand, resting palm up, projects past the patient's left side The thighs are at right angles to the surface on which the patient is kneeling With the patient in this position the physician can observe readily the part to be examined

The left lateral or left Sims' position is of unusual value in examining patients confined to bed, but it is so satisfactory that some physicians employ it exclusively for examination, operation and postoperative care

When the patient is on his left side with only one pillow under his head, his left arm should be pulled under his body toward his back



Fig 408—Knee chest position for proctoscopic examination Observe upright position of thighs the rotation of the head and the position of the right arm

This will roll his right shoulder forward toward the surface on which he is lying His left thigh and leg should be straight with relation to his body and his right thigh and leg are flexed (fig 407) This position does not provide as satisfactory an opportunity for comparison of the medial surfaces of the right and left gluteal surfaces and perineal regions nor is it as easy to provide satisfactory illumination as the other two positions In addition it requires the almost continued use of the patient's right hand or one of the physician's hands to provide satisfactory exposure

The minimal equipment necessary to arrive at a satisfactory proctologic diagnosis should be mentioned The table designed by Bue has been described however a regular examining table may be used

It is hardly necessary to mention finger cots and a satisfactory non-irritating water-soluble lubricant. The anosopes and proctoscopes that may be used will be described later.

As essential as any piece of apparatus or all of the apparatus, is the physician's manner of conducting the examination. He must realize that the patient is compelled to rely on him not only for the result of the examination, but also for the manner in which the conclusion is reached. It is undeniable that, without care and dexterity on the part of the physician and co-operation on the part of the patient, the examination is painful and often fails of accomplishment. No ironbound course can be pursued in obtaining the patient's co-operation. It appears best to assume that the patient intends to co-operate and then



Fig. 407.—Left lateral or Sims' position. Observe the position of the left and right thighs and the left arm.

to warn him of each step. These warnings should be stated so that the patient will understand promptly. If the patient is extremely apprehensive, the first step or two of the examination will either build or destroy his confidence and his ability to co-operate.

INSPECTION

The sacral, gluteal, anal and perineal regions must be exposed and this exposure must be arranged so that the patient will be embarrassed as little as possible, yet so that all of the parts can be observed easily and comfortably. Some physicians lacking the finest equipment feel greatly handicapped and do not make adequate examinations while others who have discovered the need of accurate proctologic diagnosis insist on following the suggested procedure in spite of almost insurmountable difficulties.

Satisfactory illumination aids accurate observations and also enables the physician to take advantage of the opportunity to compare similar

right and left portions of the body to detect dissimilarities. Such light need not be too bright but it should be situated if possible so that it will cause minimal shadows. If the patient must remain in bed, however, or if his motion is limited because of illness, orthopedic appliances or other restrictions, the examining physician will be compelled to improvise exposure and illumination, but if the examination is necessary, it can be accomplished in all but a few cases. In unusual instances profuse diarrhea or incontinence preventing satisfactory preparation, coexisting with the other possible handicaps mentioned, may make the examiner's efforts useless.

Assuming that the patient is prepared, is in one of the recommended positions and is draped with a small sheet to avoid embarrassment and that the light is satisfactory and the instruments are sterile and in working order, examination can continue. Before touching the patient, what can be detected? A perianal dimple often can be observed, but it is of little consequence since it usually signifies only the presence of a congenital deformity of the tip of the coccyx.

When the skin in the sacrococcygeal region has a cribriform appearance and a sinus or sinuses are associated which may extend to the right or left, above or below as far as the perineum, or may closely simulate a fistula, an infected pilonidal cyst probably is present. If the condition is observed before incision or spontaneous drainage has occurred the pilonidal cyst may appear as a reddened elevated area which will prove tender if palpated.

Lipomas are observed as fairly sharply demarcated swellings causing little or no discoloration of the overlying skin. Neurofibromas are observed as smaller swellings. Papillomas and moles are frequently seen.

At times perianal or ischiorectal abscesses can be seen as can thrombosed edematous external hemorrhoids. If an abscess is present, it frequently will cause unilateral distortion of the contour of the gluteal surface. Herpetiform lesions frequently are observed. Urticaria, psoriasis, dermatitis medicamentosa, dermatitis venenata, actinodermatitis and pyoderma also may be observed. Occasionally narcotic addicts inject the substance in the gluteal region with resulting inflammatory reaction or tattooing. Extravasation of blood following injury is also common and should lead to added questions concerning the patient's tendency to bleed. All of these conditions and others can be observed without touching the patient.

PALPATION

The examiner should touch the patient very gently, cautiously palpating the exposed surfaces and he should warn the patient before touching any lesion that may be tender. He should never cause discomfort immediately.

It is worthy of mention that less pain will result if a tender part is palpated with the surfaces of the distal portions of the fingers rather than with the tips. Palpation is as important as any other portion of the examination because it reveals many physical factors that are not discernible by inspection. The density of the lesion, fluctuation, adherence to the underlying or the more superficial tissue and pulsation can be determined. It can be ascertained whether motion of the lesion is synchronized with underlying muscle or vascular tissue, whether the lesion is associated with specific areas as anal crypts or the sacrococcygeal region and whether blood or other fluid discharges escape as a result of pressure on the mass. Other conditions can be found by this method but it seems sufficient to illustrate that palpation corroborates the knowledge gained by close visual examination and reveals the presence of lesions which cannot be seen.

Examination of the perianal skin, adjacent gluteal surfaces and perineum which requires lateral retraction might be considered part of examination by palpation. Retraction must be accomplished gradually and a shift of retractive effort cannot be hurried because the patient resists continued examination unless these cautions are exercised. Once the patient's tolerance or co operation is altered unfavorably, it is difficult or impossible to regain it.

When the gluteal surfaces are retracted laterally so that the anus is exposed a different and perhaps more important group of lesions may be observed. External anal tags can be seen and differentiated from external hemorrhoids. A thrombosed external hemorrhoid may be differentiated from a comparatively rare melano epithelioma. The melano epithelioma is usually painless and increases in size gradually while a thrombosed hemorrhoid is usually painful and diminishes in size gradually. The thrombosed hemorrhoids may be multiple. When they are associated with edema, the thrombi are obscured by swelling.

An acute abscess may be found in the anal, perianal, gluteal or perineal tissue. Such a lesion may be extremely small and cause a slight smooth elevation which may or may not be reddened, fluctuant or firm but almost invariably is tender. When the abscess has ruptured a subacute abscess or fistula which has one or many secondary external openings, usually results. The tracts of the fistula can be palpated with little pain and yet this palpation may reveal more than many attempts to probe them.

Acute or chronic draining sinuses with no palpable tract leading to the anus or to the sacrococcygeal region may be pyoderma which may originate as hidradenitis suppurativa. The presence of pyoderma can be verified often by other involvement in the perineum, suprapubic region and axillae. It frequently coexists with extensive or mild acne. The patient is usually twenty to thirty years of age.

Perianal condylomas, perianal comedones with resulting furuncles

leukoplakia, leukokeratitis, anal pruritus and vitiligo are often present and they can be exposed by slight retraction of the gluteal surfaces adjacent to the perianal skin. In addition actinodermatitis, psoriasis, herpes, dermatitis medicamentosa, dermatitis venenata and chancre may be observed. Actinomycosis, lymphosarcoma, sinuses from tuberculosis involving the pelvis, or osteomyelitis may be diagnosed more rarely. Even more rarely a firm nodular mass situated at or near the anal margin closely adherent to the underlying tissue and covered by normal skin may be observed and when a specimen is removed it may prove to be a leiomyosarcoma. Ulceration in the perianal skin which extends into the anus may be caused by tuberculosis, epithelioma or carcinoma or it may be the only visible evidence of regional enteritis.

Anal pruritus can be detected usually by the fairly typical changes in the perianal skin. Pigmentation is altered frequently, the amount of hair in the involved area usually is diminished and the skin may appear thickened or thrown into increased folds. It may be reddened and dry and may feel warmer than it normally does. Other abnormalities may be associated with those mentioned.

Ectropion of the mucous membrane resulting from a previous recto- or anorectal operation may be present. Internal hemorrhoids or papillae may protrude through the anus. The anus may be relaxed as the result of prolapse of a portion of the intestine through the anus. Extensive scarring from previous operations or injury may be observed. A congenital deformity may be present. Urethroperineal fistula may have developed. Pseudosinuses may confuse the picture but the lack of inflammatory reaction or scarring surrounding them assists in making the diagnosis.

A thorough examination of the exposed and exposable portions which have been considered should always be accomplished before attempting digital examination because it will enable the physician not only to diagnose a number of interesting lesions but also it will enable him to examine the anus digitally with minimal difficulty.

Digital Examination—Digital examination can be made satisfactorily if the physician standing to the left of the patient will employ the index finger of the left hand and if standing to the right of the patient the index finger of the right hand. The former is preferable. In either case the remaining fingers should be loosely clenched and during the examination they should be situated over the midline posterior to the anus.

It is best to place the nonirritating water soluble lubricant on the anus and then insert the finger. The insertion should not be accomplished until the patient has been warned about what is going to happen and has been reassured. The physician may say, "Let me try to insert my finger, I'll be careful" or something to this effect. This explanation will assist in overcoming the natural tendency of every

patient to contract the anal sphincter. It is advisable also to palpate the anal margin with the cotted finger before inserting it into the anus. This will assure proper lubrication, assist in calling to attention any palpable masses and also it is a means of further assuring the patient of the examiner's intention to be careful. If a painful lesion is found in the anal canal pressure should be exerted on the opposite side of the anus as the finger is inserted slowly and reassurance is given.

As the examining finger is being inserted slowly, every abnormality should be noted and its identifying characteristics catalogued mentally. Where is the lesion? Is it tender, firm, nodular, movable? Are there more than one? Is the lesion attached to overlying and underlying tissue? Is it superficial or deep? Is there a foreign body in the lumen? Is the lesion annular? Does it encroach on the size of the lumen and are there other factors which can assist the examiner to characterize the lesions present for the purpose of diagnosis? The anal lesion can be described as being situated on or in the right, left, anterior or posterior quadrants.

The finger should be inserted to its full length and then the posterior quadrant of the anus can be displaced in a cephalad direction if the anus is not too tender. By this maneuver 1 to 2 inches (2.5 to 5 cm.) more of the intestine can be palpated. This is one of the distinct advantages of this method of digital examination. As the finger is inserted slowly into the anus the approximate diameter of the anus and the action of the sphincter muscles may be observed. Thrombi which cannot be seen may be palpated. Posterior or anterior anal fissures can be detected as can enlarged papillae whether they are associated with the fissure as they frequently are or not. Sometimes internal hemorrhoids can be palpated but this is an inaccurate way in which to make such a diagnosis. It is better to visualize them. Firm nodules which may be leiomyomas often are palpated in the region where internal hemorrhoids appear. These result from injection treatment. Sometimes internal abscesses or complete internal fistulas may be mistaken for such nodules on digital examination because they are situated in similar areas and often feel equally firm. It may be necessary to examine the patient under anesthesia before the diagnosis can be made accurately. Movable, firm extrarectal nodules situated anteriorly just above the dentate margin or on either side of the prostate gland or just above it may be phleboliths. Sessile or pedunculated polyps may be detected at any level above the dentate margin. At any level there may be found a rectal stricture which may have resulted from venereal lymphogranuloma, chronic ulcerative colitis, carcinoma, previous rectal or anorectal operations, injection treatment to obliterate internal hemorrhoids, tuberculosis or enigmatic causes. Usually microscopic examination of a specimen, Frei test, proctoscopic examination and other corroborating information are necessary to determine the cause.

of the stricture. The primary or rectal opening of a rectovaginal fistula if present usually may be palpated anteriorly at or just above the dentate margin.

A carcinoma may be situated at any level and it may involve any portion or all of the circumference of the lumen. A colloid carcinoma is often difficult to diagnose accurately from palpation and it usually requires microscopic examination of a specimen. Epitheliomas occur in almost any palpable area although they are observed more frequently as an ulcerating tender lesion involving the anal or perianal skin. The same is true of lymphosarcomas which may resemble almost any other lesion. An extrarectal transverse ridge of infiltration situated above the prostate gland or in the cul de sac may be a rectal shelf indicating that a malignant lesion is present in the upper part of the digestive tract. The wall of the large intestine may be involved secondarily.

Bony deformities of the pelvic structures can be detected digitally and the diagnosis can be confirmed by roentgenologic examination. Uterine deformities and deformities of other pelvic soft tissue may be palpated but these abnormalities often are palpated more accurately with the patient in the dorsal position with the thighs and legs flexed. When the patient is in this position pressure may be applied to the hypogastric region to force the viscera toward the finger in the rectum. In the male prostatic abnormalities as well as those in the seminal vesicles may be felt. Dermoids, sarcomas, cystic extrarectal masses and neurogenic lesions all occur in this region and often are palpable through the rectum. Foreign bodies such as bones and innumerable unimaginable curiosities have been palpated. A palpable fecal impaction may be the cause of a patient's discomfort.

While the examining finger is being withdrawn from the anus and rectum the effort to palpate surrounding tissues should be just as diligent and alert as it was during the insertion of the finger. To complete the digital examination it is well to note the fingercot to detect any blood streaks which may be present. It should also be part of digital examination to determine the length of the anal canal, size of the prostate gland and to elicit any other information which will facilitate insertion of the proctoscope.

PROCTOSCOPIC EXAMINATION

A set of Hirschman anosscopes (fig. 408) small, medium and large is satisfactory for examining the anal canal and lower part of the rectum. The choice of proctoscope or sigmoidoscope may be left to the physician. At the Clinic we have found the Buie proctoscope most satisfactory. The simplicity of construction and balance are of value and the tube being almost unhampered by a projecting light permits manipulation of swabs, suction, removal of specimen, fulguration and

other manipulations which may be necessary (fig 409) To illuminate the Hirschman anoscope, the light carrier of the sigmoidoscope is employed A transformer to change current of 110 volts to 6 volts is necessary A specimen remover is essential A suction tip with a suitable controllable source of suction is helpful Several satisfactory types of apparatus are manufactured which dispose of the material removed from the large intestine by passing it directly into the waste pipe of a lavatory or sink

The anoscope and the proctoscope afford an opportunity actually to see the internal surface of a portion of the gastro intestinal tract and hence to discover lesions and abnormalities While the etiology

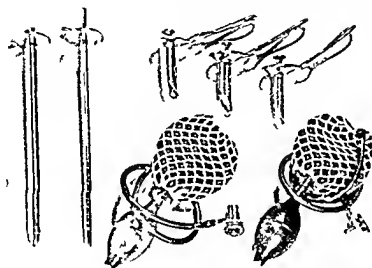


Fig 408—Instruments for proctoscopic diagnosis Left to right regular and small proctoscope, large medium and small Hirschman anoscopes and insufflating bulbs for the proctoscopes

of all of the conditions cannot be explained, it would seem that observation and recording of lesions in situ would stimulate study There seems to be little variation in the length of an anoscope, although the design may vary greatly This is not true of a proctoscope, however, for it may vary from the length of an anoscope to 18 inches (46 cm) long For the purpose of this presentation, the instrument will be considered to be 10 inches (25 cm) long

A regular proctoscope is about $\frac{5}{8}$ inch (1.6 cm) in diameter and a proctoscope of smaller caliber is usually about $\frac{3}{16}$ inch (.5 cm) The smaller instrument is employed for examining strictures and contracted anal canals, and in any situation in which the size of the lumen is limited Most children and babies, if normal, can be examined with

the large instrument Under ordinary circumstances, the large instrument can be inserted more readily and the observations are more thorough and accurate than they would be if the smaller instrument were employed

The proctoscope should never be inserted until the anus has been examined digitally because this process dilates the anus slightly and furthermore it prevents the possibly brutish effort to insert the proctoscope when a portion of the anus is acutely tender The lubricant should be placed on the anus again as it was for digital examination and the proctoscope is inserted through the anus slowly in an effort to avoid sudden insertion when the tip of the instrument slips past

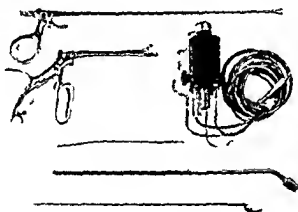


Fig 409—Accessories for proctoscopic diagnosis observed from top to bottom specimen taker punch for the removal of specimens from the perianal skin transformer with cords silver probe suction tip and cotton swab

the grasp of external sphincter muscle The thumb of the physician's right hand should be held over the top of the handle of the obturator until the instrument has been inserted just inside the sphincter and then the obturator should be withdrawn The examination should be continued under direct vision

Just before insertion of the proctoscope the patient must be warned that something about the size of the finger is to be inserted very gently If the instrument does not pass into the rectum readily it should not be twisted or forced but removed and more lubricant applied to the anus Then the attempt should be repeated and doubtlessly will succeed In the course of examination it is inadvisable to inflate the large intestine, but a small amount of air in the inflating

bulb may be employed to separate adherent folds of mucous membrane or to force a small amount of fluid out of the field. These advantages are obtained by squeezing the partially filled bulb rather sharply and maintaining slight pressure with the right hand as the proctoscope is inserted by the left hand assisted by the right. After a little experience, the use of the right hand for the two tasks is not awkward.

Proctoscopic examination verifies the presence of many pathologic processes. Some abnormalities which can be palpated on digital examination are seen and others which cannot be palpated are discovered. The proctoscope may serve also to reveal palpable extrarectal masses and other changes of interest which may be beyond the reach of the examining finger. The firmness of a lesion, its movability and the limitation of motion of the bowel may be determined. Sometimes expression of tiny fecaliths may disclose diverticula and other functions of and diagnostic uses for this instrument will increase in number with experience with this type of examination.

If the obturator is withdrawn from the proctoscope as suggested, the tip of the instrument will be situated just above the anus and the internal sphincter muscle. Ordinarily, examination is carried out most diligently at the time that the instrument is being withdrawn but careful observations should be made during insertion of the instrument. A special effort should be made to observe the abnormalities that were palpated, then further exploration should be carried out. At first the patient will feel as though nothing could possibly interfere with evacuation of the contents of the bowel. Brief explanation will help to alleviate this useless worry. Unless some abnormality or pathologic process is present, the instrument usually can be inserted to the level of the promontory of the sacrum without difficulty or without causing the patient to experience real pain.

As the examiner guides the proctoscope into the curves and folds of the bowel above the level of the hollow of the sacrum he will usually cause the patient to complain of discomfort. The patient may try to prevent examination of the rectosigmoid and sigmoid but gentleness and a warning of oncoming discomfort accompanied by instruction to the patient to continue to breathe normally, to avoid straining and to avoid moving frequently will prevent an impasse. Quiet sympathetic guidance, quiet explanation of the need for continuing unwavering insistence and other variations which the physician will learn to employ will contribute to successful examination. It is true that all patients cannot or perhaps will not undergo proctoscopic examination but with added experience the physician will observe a continued diminution in the number of patients of this type that he encounters.

The possibility of perforating the wall of the bowel always should be kept in mind. To avoid this catastrophe the proctoscope should

never be inserted unless the lumen into which it must be inserted is visible. Adult patients should not be allowed to take sedatives prior to examination. Many children who will listen to and co operate with their parents will also co operate with the physician if he does not disturb their youthful dignity by a noisy enthusiastic greeting and boisterous misleading statements concerning the examination. If the child's dignity is preserved and his co operation is assumed he is often a more co operative patient than his elders. When the child argues with his parents and in a borderline tantrum refuses to listen to anything that is said it may be necessary to administer enough sodium amytal to decrease his resistance.

The interior of the wall of a normal bowel is pink glossy and usually moist but the color may vary in the same patient in the same day and the amount of moisture present also varies. Usually no magnifying lens need be employed to detect abnormalities in the mucosa.

The mucosa displaying melanosis coli will appear glossy and moist but will be brownish pink to black and marked with yellow striations or dots. The yellow markings may appear to be elevated slightly at first glance but closer scrutiny will disprove this.

Polyps of all sizes in any location sessile or pedunculated, and solitary or multiple are observed frequently. Their destruction or removal is a sound preventive surgical procedure. Carcinomas lymphosarcomas epitheliomas lipomas hemangiomas fibromas leiomyomas are among the lesions which may be diagnosed on proctoscopic examination and frequently removal of a specimen through the proctoscope confirms the diagnosis except in hemangiomas in which injury may cause dangerous hemorrhage. Sacculations observed in the rectosigmoid and sigmoid often suggest the presence of diverticula but roentgenographic examination is necessary before the diagnosis can be confirmed. Sometimes a firm extrarectal mass 4 to 5 inches (10 to 13 cm) above the anus in a woman may indicate the presence of an endometrioma or a uterine fibroma. Occasionally when women have undergone pelvic operation before proctoscopic examination it is impossible to introduce the instrument for its entire length because of a sharp angulation and the limitation of motion of the bowel which may follow operation. When megacolon is present insertion of the proctoscope will prove almost effortless but a barium enema and roentgenologic study will provide a more accurate basis for comparison with the normal bowel.

The search for small foreign bodies often proves to be difficult because of the presence of so many folds in the mucous membrane and the edges and shelving of rectal valves. Larger foreign bodies may require manipulation with and through the proctoscope.

A distinct challenge is offered in the diagnosis of ulcerative processes or diseases such as (1) chronic ulcerative colitis with the

granular appearance of the mucosa which bleeds on slight injury and in which the lumen of the bowel is contracted, (2) amebic ulceration involving the valve edges or prominent folds presenting umbilicated punched-out ulcers in otherwise normal mucous membrane, (3) bacillary dysentery with superficial ulcers in a reddened and often bleeding mucosa and (4) tuberculous ulcers occurring at any level with irregular overhanging edges in a patient otherwise ill with tuberculosis. These conditions usually require one or several of the following so that the diagnosis can be made: stool examinations, roentgenologic studies, removal of specimens for microscopic examination and cultures. Sometimes diagnosis of rare ulceration, such as that resulting from self-inflicted trauma or that caused by histoplasmosis, will challenge the examiner and he may need the aid of other diagnosticians. The peculiar proctitis which may follow the application of radium to the uterine cervix is usually so typically situated and the history of the preceding treatment so easily determined that there seems little difficulty in arriving at a correct diagnosis—factitial proctitis with or without ulceration. Purpuric hemorrhages in the mucous membrane in all stages of absorption are never forgotten if once observed, but the presence of the disease usually is known before the bowel is examined.

As the proctoscope is withdrawn close to and through the anus, rectovaginal fistulas and the primary openings of anal fistulas may be observed. Internal hemorrhoids, enlarged papillae, and anorectal scarring may be found also. Specimens can be removed from lesions in this region which are suspected of being malignant. It is tactful to wait until the examination is almost completed before carrying out some of the unavoidably uncomfortable task such as the removal of a specimen close to or in the anal canal or a very thorough digital examination to search for some deeply seated abscess.

Proctologic diagnosis is not always void of the excitement associated with an emergency procedure. Perforating lesions in the perineum or near the anus provide problems necessitating the clear thinking required in an emergency as well as the sound evaluation of the extent and import of the injury. Later, observation to determine the progress of healing and to anticipate undesired deformity may prove helpful.

Less thrilling but more frequently requested is the information which may be obtained by the proctoscopic examination of colonic stomas. This procedure can be most useful in the differentiation between carcinoma and diverticulitis. It may be employed to search for polyps or ulceration or only to note the progress of a healing wound. Sometimes the search for recurrence of a malignant lesion will disclose proliferative tissue at the site of the resection and the physician usually will learn the need of removing a specimen for microscopic study rather than attempting diagnosis from the gross appearance of the tissue.

The examination and diagnostic evaluation of congenital deformities test the physician's knowledge of embryology. These deformities usually result from arrested development and frequently they represent only one of a group of deformities which may occur congenitally. The task may be simplified or complicated by remedial attempts made prior to this examination.

This discussion has not dealt with the minutiae of diagnosis of lesions, but it has been an effort primarily to indicate the variety of diagnostic opportunities. The opportunity to apply special diagnostic knowledge should prove stimulating. Each observation of common or unusual lesions encourages the proctologist to continued effort. It seems undeniable that prompt proctologic diagnosis is lifesaving in many cases. Proctologic diagnosis is important in the practice of modern medicine and surgery.

PROTRUDED INTERVERTEBRAL DISK

J GRAFTON LOVE

PROTRUSIONS of intervertebral disks have been established thousands of times without peradventure as the anatomic and pathologic factors in intractable nerve root pain disabling low back and sciatic pain brachial neuritis and paraplegia By "root pain" is meant pain that is felt along a spinal nerve root or the peripheral nerve taking its origin from the root involved This pain is usually aggravated by coughing sneezing and straining at stool and it oftentimes is present at night and disturbs sleep

As a result of the observations by members of the staff of the Clinic, we have come to rather definite conclusions regarding the etiology diagnosis treatment and prognosis in cases of protrusions of the intervertebral disks Some problems still remain unsolved For instance the exact indications for combining a fusion operation with removal of protruded intervertebral disk and the length of time a patient should undergo conservative treatment before resorting to operation are not entirely clear Solution of these two problems probably will not provide a set of rules that are applicable in all cases Nevertheless most of the principles of treatment in cases in which protruded intervertebral disk is suspected are fairly well established This does not mean that all patients with low back and sciatic pain, for instance are treated in a routine way No satisfactory routine for the treatment of those who are disabled and ill can be formulated Each individual case must be considered if best results are to be obtained

At the Clinic we still feel as do most investigators that protruded intervertebral disks are caused in the main by trauma The trauma often is in the form of unusual stress or strain to the back while in a flexed position This type of trauma has been repeated often and for this reason it is at times difficult or impossible for the patient to state the exact time of onset of symptoms This fact of course complicates the problem as far as reports for insurance compensation and disability are concerned At times the patient can tell of one specific isolated injury to his back such as a jolt which forced him to sit down with his spinal column flexed and gave rise to back pain or snapping of the back while he was forcefully lifting a heavy object

When the patient has difficulty recalling any undue stress or strain to the back if he is not engaged in a heavy occupation the question of a degenerative lesion as the cause of the protrusion arises

Intervertebral disks in the lumbar portion of the spinal column are the ones most often protruded These lesions are diagnosed more

easily than those that occur in the cervical and thoracic portions of the spinal column but I am sure the high incidence in this segment is due to something more than easy diagnosis. Some intervertebral disks are more vulnerable than others. More than 90 per cent of the protruded lumbar disks occur at the last two lumbar interspaces whether the patient has the usual five lumbar vertebrae or the less common four or six lumbar vertebrae.

DIFFERENTIAL DIAGNOSIS

Although the neurologic examination is helpful in the diagnosis and localization of protruded intervertebral disks, it cannot be relied on in all cases. Absence of an Achilles reflex more frequently means a protrusion at the lumbosacral interspace than at one of the other interspaces, but many times we at the Clinic have removed a protrusion of the fourth lumbar disk which has produced the patient's symptoms and signs including absence of the Achilles reflex. I also have removed two neurofibromas from a nerve root in the upper part of the lumbar region in a case in which the history and findings were indicative of involvement of the first sacral root by a protruded lumbosacral disk. Motor weakness and atrophy of the calf muscles occur but these signs are not common when only one nerve root is affected. Rarely foot drop will occur as the outstanding neurologic sign in protrusion of a lumbar disk.

Ordinary roentgenograms of the spinal column should be made in all cases in which the presence of a protruded intervertebral disk is suspected. Primary and metastatic neoplasms must be excluded. Rheumatoid arthritis occasionally will mimic a protruded intervertebral disk. More rarely a protruded intervertebral disk may be present in association with rheumatoid spondylitis. Spondylolisthesis and spondylolysis also must be detected by roentgenographic visualization of the spinal column. The finding of a separation of the neural arch does not exclude protruded intervertebral disk for protrusions of lumbar disks in association are rather frequent.

In simple protrusions of intervertebral disks, the spinal column may appear to be perfectly normal in the roentgenogram. Narrowing of an interspace may be slight to marked. Congenital anomalies such as spina bifida occulta, bifurcation of a transverse process or unilateral or bilateral sacralization of the transverse process of the last lumbar vertebra may be present or a high riding first sacral segment may be found. The importance of these congenital anomalies in cases of protruded intervertebral disks is not fully understood, but they probably are of little significance.

It is my feeling that in all cases in which the presence of protruded disk is suspected lumbar puncture with examination of spinal fluid should be performed before operation.

Diagnosis of most lesions in the cervical portion of the spinal column can be made without myelography. Diagnosis of most lesions in the thoracic part will require myelography with an opaque medium such as lipiodol or pantopaque. If an opaque oil is used it should be removed immediately after examination. If lumbar lesions are present the lumbar portion of the spinal canal should be visualized after injection of air or oxygen. It is true that the majority of the protrusions of lumbar disks occur at the last two lumbar interspaces and these two interspaces are explored easily through a short incision but it is equally true that a protrusion of a third lumbar disk will at times mimic a lower lesion completely. Also protruded intervertebral disks are frequently multiple (about 10 per cent). Recently I removed a protrusion from both the third and fifth interspaces at the same operation and one of these undoubtedly would have been overlooked if a preoperative spinogram had not been made. Occasionally not rarely a neoplasm of the spinal cord is suspected first when the protein content of the spinal fluid is reported to be unusually high (more than 100 mg per 100 cc) or a defect characteristic of neoplasm rather than of protruded intervertebral disk is seen in the spinogram.² It is important to emphasize the fact that spinograms often fail to show any defect when a protruded intervertebral disk is present. This should not deter the experienced surgeon from carrying out necessary treatment. The spinogram is a laboratory procedure and must be interpreted in the light of the patient's history and examination. When results of spinographic examination are positive but the history and findings do not indicate the presence of a lesion the spinogram should be disregarded. When results are negative and the clinical findings are positive it also should be disregarded.

Cases 1 and 2 presented difficulties in the differential diagnosis but the diagnosis was made before operation.

CASE 1—In 1945 the patient a white woman twenty three years of age came to the Clinic. Four months before she had undergone elsewhere laminectomy of the fifth lumbar vertebra with attempted fusion of the lumbosacral region because of midline lumbosacral pain. This pain had been aggravated when she walked or laughed but it did not extend into either extremity. Strangely enough immediately following operation the back pain had been relieved but as soon as the patient returned to her home she began to have the same discomfort in the lower part of the back and in addition pain extended into the left groin. She was in bed from the time that she returned to her home from the hospital until she was brought to the Clinic on a stretcher. On admission to the Clinic the patient was hospitalized. She was in so much pain and was so emotionally upset that neurologic examination was almost impossible. However except for slight reduction in the patellar reflex bilaterally no changes in the reflexes were observed. It was impossible to demonstrate any loss of sensation. The patient could not stand up so that her ability to walk and spinal motion could not be tested. The marked weakness of the lower extremities seemed to be due to pain and fear.

Lumbar puncture was performed at the second lumbar interspace the fluid

was found to be yellow a subarachnoid block was present and the total protein content of the fluid was 2500 mg per 100 cc

A diagnosis of tumor of the spinal cord was made and operation for its removal was advised. A large, hemangio-endothelioma opposite the second, third and fourth lumbar vertebrae was removed through a laminectomy wound.

The patient's convalescence was entirely uneventful. By the fifteenth day following the operation she was up and walking around the hospital unassisted and without fear.

A diagnostic lumbar puncture prior to the original operation might have prevented the previous useless procedure.

Case 2 is another case in which neurologic examination was misleading and without a spinogram the exact site would not have been known.

CASE 2.—The patient, a physician forty years old, came to the Clinic complaining of low back and left sciatic pain which had had its onset twelve years before. The pain was present in the lower part of the back and it extended down the left lower extremity to the ankle and large toe. Coughing, sneezing and motion aggravated the pain.

Neurologic examination revealed that the patellar and Achilles reflexes were normal. The only sensory impairment was in the third lumbar dermatome on the left. Visualization of the spinal canal after injection of air revealed a deformity of the air column at the fourth lumbar interspace and no air opposite the fifth lumbar interspace. These findings suggested either a large protrusion of the fourth lumbar disk or protrusions of the fourth and fifth lumbar disks. The spinal canal was normal opposite the upper three lumbar interspaces. The concentration of protein in the spinal fluid was 60 mg per 100 cc.

At operation a midline protrusion of the fourth lumbar disk and a left lateral protrusion of the lumbosacral disk were removed and pain was relieved.

PROTRUSION OF CERVICAL INTERVERTEBRAL DISK

When protrusion of a disk occurs in the cervical portion of the spinal column a lower cervical disk most often is affected. The protrusion usually results from injury to the neck. The symptoms may follow immediately on injury or occur subsequently. The symptoms may consist of root pain or they may be those of compression of the cervical portion of the spinal cord depending on whether the fragment of cartilage projects into the spinal canal laterally and irritates and compresses one nerve root or projects medially and compresses the spinal cord itself.

When root pain is present good results are obtained from removal of the offending fragment of protruded disk. Compression of the cord is a much more serious problem and oftentimes irreparable damage has occurred to the cervical portion of the spinal cord before the compression is relieved.

Case 3 illustrates a typical protrusion of a cervical disk and what can be expected from surgical treatment.

CASE 3—The patient, a white man forty five years of age was referred to the Clinic. His chief complaint was of nerve pain in the left arm of four months duration. The history revealed that he had been in an automobile accident six years before, but so far as he knew he had no ill effects from the accident. Four months before coming to the Clinic, he twisted his neck suddenly and one hour later a tingling sensation developed in the left thumb. He related that the sensation had felt like an electric current going into the thumb and this distress had been constant for six weeks. He had received osteopathic treatments and the sensation had disappeared but since the onset he had had mild aching to the left of the midline of the neck from the upper portion of the trapezius muscle down to the deltoid region and in the middle third of the posterior part of the left forearm on the radial side. Three weeks before examination at the Clinic this pain had become severe and had continued. The pain was made worse when he turned his head to the left or extended his neck. Coughing did not increase pain. Acetyl salicylic acid did not relieve it. The pain disturbed his sleep and varied in intensity during the twenty four hour period.

Results of neurologic examination were objectively negative. Bending the neck to the left or backward produced and aggravated the pain. Scalene maneuvers did not reveal any abnormalities. On orthopedic examination it was noted that the patient tended to hold his head tilted forward and some tenderness was found to the left of the midline of the cervical vertebrae. Movements of the arm and shoulder were normal. Roentgenologic examination of the cervical portion of the spinal column revealed some arthritic changes involving the vertebrae and a healed fracture of the spinous process of the sixth cervical vertebra.

Because the symptoms and signs were consistent with the diagnosis of protruded cervical disk, lumbar puncture was advised. Evidence of a subarachnoid block was not found, the fluid was clear and the concentration of protein was 40 mg per 100 c.c. of cerebrospinal fluid. Laminectomy for the removal of a protruded intervertebral disk was advised.

The patient was placed in the upright position which is used for operations in the posterior fossa of the cranium and for cervical laminectomy. The cervical muscles were reflected on the left side opposite the spinous processes of the fifth, sixth and seventh cervical vertebrae. The left lamina of the sixth cervical vertebra was removed. At the upper lateral angle a nerve root compressed by a protruded disk could be palpated. Congestion was marked around the nerve root and the root was displaced backward by the protruded disk. Then the left lamina of the fifth cervical vertebra was removed in order to pack off the large congested vessels and isolate the sixth cervical root as it crossed the fifth cervical interspace. Multiple small fragments of fibrocartilage which constituted a typical protrusion of the cervical disk were removed. This freed the nerve root entirely of pressure. A small pledget of muscle was used to control bleeding from the large extradural vessel above the nerve root and the wound was closed in layers without drainage.

Fifteen days later the patient was dismissed from the Clinic. The wound had healed by primary intention and the stiffness of the neck which had been present prior to operation was subsiding. Four months later the patient was re-examined and at that time the results were considered to be good.

Unilateral approach which usually requires hemilaminectomy should be employed in removal of the protruded portion of the cervical disk if root pain is the principal symptom. If the spinal cord is compressed by a large midline protrusion, then bilateral laminectomy often is necessary. The articular facets should be preserved always to maintain stability of the cervical portion of the spinal column.

PROTRUSION OF THORACIC INTERVERTEBRAL DISKS

Protrusions of thoracic disks have been encountered rarely at the Clinic, possibly because they occur infrequently and are difficult to diagnose. The symptoms may be root pain or paraplegia depending on the size and position of the protruded fragment of the disk.

A typical case of protrusion of a thoracic disk is illustrated by case 4.

CASE 4—The patient, a man, was forty years of age at the time of operation in December 1937. He had been coming to the Clinic for three and a half years because of backache which was ascribed to lumbosacral arthritis. In 1934 roentgenologic examination of the spinal column revealed definite lumbosacral arthritis. In December 1937 the patient was referred to the neurologic section for a check up prior to consideration of an operation to bring about lumbosacral fusion. It was learned that at the age of sixteen or twenty-four years before he had begun to have attacks of lumbago about twice a year. Since 1927 he had had constant dull aching pain across the lower part of the back which was aggravated by motion.

The neurologic examination gave entirely negative results. A marked change was shown at the lumbosacral space in the roentgenograms and it seemed unlikely that this was the entire cause of the patient's backache since he had not had any extension of pain to the sciatic region. It seemed that, with the changes present, if the backache were due to the lumbosacral arthritis, one or both sciatic nerves would have become involved secondarily.

A combined lumbar puncture and epidural injection was advised and was performed with a caudal needle in the sacral hiatus. Each time a fraction of 10 cc. of 1 per cent solution of procaine hydrochloride was injected the patient complained of severe sharp pain in the lumbosacral region. Pain did not extend to either hip or leg. A spinal puncture needle was introduced into the fourth lumbar interspace and clear fluid was obtained. No evidence of subarachnoid block was found at this time nor when the reverse Queckenstedt test was made. A specimen of fluid was removed for examination and it was reported that it contained total protein of 120 mg. per 100 cc. The elevated level of total protein in the spinal fluid seemed to indicate that an intraspinal lesion was the cause of the low back pain.

On December 14, 1937, 5 cc. of radiopaque oil (lipiodol) was introduced into the first lumbar subarachnoid space for roentgenoscopic examination. This disclosed a persistent defect opposite the interspace between the eleventh and twelfth thoracic vertebrae. On December 20, 1937, laminectomy consisting of the removal of the spines and laminae of the eleventh and twelfth thoracic vertebrae was performed. The ligamentum flavum between the eleventh and twelfth thoracic laminae was thickened and fibrotic, particularly on the right side. Extradurally and anteriorly on the right was a protrusion of the intervertebral disk. The dura sac was retracted to the left, the eleventh thoracic disk popped out and thus relieved the spinal cord of compression. The dura mater was opened, the radiopaque oil was washed out and the dura mater was sutured with a stitch of continuous silk.

Following operation the patient made an uneventful recovery and was completely relieved of his backache. I have had an opportunity of seeing this patient frequently since operation. He has worked full time since shortly after operation and has had no further trouble with his back. The lumbosacral arthritis, of course, persists.

In removing the protruded portion of thoracic disks, bilateral laminectomy usually is performed in order to obtain adequate expo-

sure and to avoid trauma to the spinal cord. The articular facets should be preserved although in the thoracic region this is not as important as it is in the cervical portion of the spinal column.

PROTRUSION OF LUMBAR INTERVERTEBRAL DISKS

Protrusion of a lumbar disk produces low back or unilateral sciatic pain or both in the vast majority of cases. In about 2 or 3 per cent of cases, paraplegia will be present at the time of operation because the protrusion is unusually large or because onset of symptoms is unusually sudden and the cauda equina has not had time to adjust itself to the pressure exerted by the cartilage.

The patient usually limps or has so called sciatic scoliosis or tilt of the pelvis. The scoliosis is usually away from the side of the pain although it may be toward the pain. Scoliosis may be evident only on flexion of the back. He handles himself carefully in order to avoid aggravation of this pain. The back is usually flattened with loss of the normal lumbar lordosis and the erector spinae muscles are in spasm. Motions (especially hyperextension), active and passive, of the spinal column are painful and limited. Usually localized tenderness is present in the lumbosacral region. The straight leg raising test is positive on the side of the sciatic pain and often lifting of the opposite straight leg is limited with reference of pain along the involved sciatic nerve.

In many cases, there is objective evidence of neurologic involvement, such as a reduction or absence of the Achilles or patellar reflexes or reduction of sensation in the skin supplied by the involved nerve root. Many patients without objective neurologic findings give a history of paresthesia in the lower extremities.

The average age of patients at the time of operation for protruded intervertebral disk in the lumbar region is about forty years. Typical protrusions have been found in a patient twelve years of age and in patients in the seventh decade of life.

In most cases at the Clinic in which the so called disk syndrome was present bouts of low back pain or sciatic pain or both had recurred for several years. Many patients have received many types of so called conservative treatment before the real cause of disability was determined or because they felt that they had responded satisfactorily to conservative treatment.

When the patient's pain and disability have become incapacitating or definite neurologic signs develop and diagnosis of protruded intervertebral disk is definitely indicated, the necessary treatment to eradicate the pathologic condition should be undertaken.

Surgical Treatment.—The operation for the removal of a protruded intervertebral disk in the lumbar portion of the spinal canal should

be that procedure which, in the hands of the particular surgeon, will give adequate exposure for the removal of the offending cartilage without undue danger of damaging the *crua equina* or other vital structures. In the majority of my cases I remove the protruded disk after unilateral subperiosteal reflection of the erector spinae muscles opposite the involved interspace without sacrifice of any bone.¹ The ligamentum flavum is resected from the base of the interspinous ligament laterally to the facets. If the interlaminal space is narrow and will not permit the introduction of the sucker tip, the right angled nerve root retractor (fig 410), or the modified Gruenwald forceps then the margin of one or both laminae is removed with the Kerrison bone biting forceps. At times the protruded fragment of cartilage is too large to be removed without removal of a portion of a lamina and

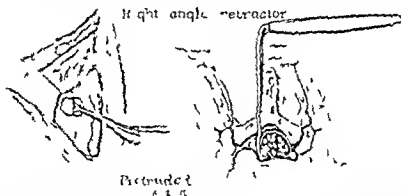


Fig 410—Extent of the operative procedure in the average case of protruded intervertebral disk. The special right angled retractor is retracting the edematous compressed nerve root and exposing the protruded disk which will be removed with the Gruenwald forceps (Love J G and Walsh M N Surg Gynec & Obst Vol 77)

again the congested extradural vessels may cause troublesome bleeding necessitating more exposure than is provided between the intact laminae.

The involved nerve root is usually hyperirritable and tense and often is bound down to the protruded portion of the disk. The root is gently freed from the protruded part of the disk and retracted out of the way by an assistant who holds the right angled nerve root retractor. If, as is often the case the fragmented cartilage is lying free in the spinal canal it is grasped with forceps and removed. Then the opening in the posterior longitudinal ligament and annulus fibrosus is searched for and any loose fragments in the space between the vertebral bodies are removed. No sharp cutting or curetting is done in the interspace and no attempt is made to remove the entire disk. If

the protruded part consists of a conical mass which is resilient when touched with a forceps, the stretched out posterior longitudinal ligament must be opened before the fragments of disk can be removed. Usually this ligament is opened easily with the end of the bayonet forceps and, as the restraining influence of the ligament is removed, the curled up protruded part of the disk unwinds itself. Then it is removed. At times the ligament is tough and incision with a ureteral or other knife is necessary to free the fragments of disk.

If the patient has had bilateral sciatic pain or low back pain without sciatica, due to a midline protrusion of a lumbar disk, it is better to reflect the muscles bilaterally opposite the involved interspace and be prepared to remove the entire ligamentum flavum and the interspinous ligament. At times it is advisable to remove the adjacent margins of the spinous processes and even of the laminae so that the entire dural sac may be elevated without compression against the neural arches while the fragmented protruded disk is removed. Originally, we removed these lesions transdurally, but that type of operation subjects the cauda equina to unnecessary risks.

After the fragmented cartilage has been removed and the cauda equina has been freed of pressure, the wound is closed in layers with out drainage.

Postoperative Care.—The patient is placed on his side in a bed that has boards between the mattress and springs and a pillow is placed at his back to prevent him from rolling over on his dressings. In the first twenty four hours he is turned by the nurses every four hours and sufficient hypnotic drugs are given to control pain. At the end of twenty four hours the patient is allowed to turn himself at will. The afternoon of the fourth day (counting the day of operation as the first) he is allowed to sit on the edge of the bed and that evening receives a dose of castor oil. The next day the patient is permitted to go to the bathroom or use the bedpan, whichever he prefers, and from then on he may be out of bed whenever he likes. The amount of walking is increased each day until he leaves the hospital, usually before the tenth postoperative day. The sutures in the skin are removed on the sixth postoperative day.

All patients at the time of dismissal are advised to spend three months convalescing before returning to their usual activities. If residual soreness is present in the back at dismissal, local heat and gentle massage are advised. The operative mortality rate in these cases has remained at 0.25 per cent in the Clinic.

COMBINED OPERATIONS

The term "combined operation" for intervertebral disk denotes an operation participated in by both orthopedic surgeon and neurosurgeon.

A combined operation is performed (1) when indications of a protruded intervertebral disk are definite and an associated condition requires fusion of the spinal column, (2) when it is not entirely certain that a protruded intervertebral disk is present but fusion is required and (3) when protrusion has occurred but the indications for fusion are not definite and the final decision must be made at operation.

For patients who have protruded intervertebral disks and also have spondylolisthesis or spondylolysis, to stabilize the abnormally unstable back spinal fusion should be performed at the time the protruded intervertebral disk is removed. Other patients are benefited by the combined operation but the indications are not as clear cut and the advice has to be based on the problems involved in the individual case. All patients at the Clinic who are suspected of having a protruded intervertebral disk are examined by both an orthopedic surgeon and a neurosurgeon and the former decides whether or not fusion should be done.

The fusion operation usually consists of the application of a massive bone graft from the tibia opposite the fourth and fifth lumbar vertebrae and upper two segments of the sacrum. Patients who have the combined operation no longer require casts and they are kept in bed for three weeks only. Thus satisfactory treatment has relieved tremendously the economic burden previously placed on these patients.

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FURTHER OBSERVATIONS ON THE TREATMENT OF CARCINOMA OF THE PROSTATE BY BILATERAL ORCHECTOMY

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FROM June 1, 1941, to December 31, 1943, inclusive, bilateral orchectomy was performed in 220 cases of carcinoma of the prostate at the Clinic. In a previous report of this group of cases, the analysis of the results was based on follow-up data which had been obtained up to May, 1944. In the present paper, we shall report further observations which are based on follow up data which have been obtained up to May, 1945.

We have been able to obtain follow up data in 219 of the 220 cases. This report will be based on the 219 cases in which follow-up data are available. Eighty-two of the patients have returned to the Clinic one or more times since bilateral orchectomy was performed. In the remaining 137 cases, follow-up data were obtained by letters of inquiry.

As we reviewed these cases, it became apparent that the entire series should be divided into two groups: (1) those in which there was clinical, roentgenographic or chemical evidence of metastasis at the time orchectomy was performed, and (2) those in which there was no evidence of metastasis when the operation was performed. From a study of these groups we had hoped to determine, among other things: (1) whether orchectomy increases the period of survival, and (2) whether it is advisable to perform orchectomy as soon as a diagnosis of carcinoma of the prostate is made, or whether it is advisable to await the appearance of symptoms or signs of metastasis. However, we are not able, at the present time, to answer these questions. We do not believe that we have followed our patients for a sufficient length of time to draw statistical comparison between this group of patients and a similar group of patients who had carcinoma of the prostate but were not treated by orchectomy. We hope to present such a comparison in a subsequent report.

We shall first consider the entire group of 219 cases in which follow up data were available. We then shall consider the 167 cases in which metastatic lesions were present when orchectomy was performed and the fifty-two cases in which there was no evidence of metastasis when the operation was performed.

SURVIVAL RATES

The survival rates, in relation to the length of time of the follow up study are shown in table 1. It will be noted that all of the 219 patients were followed for more than one year and that 78 per cent of them survived the first year, similarly, of 179 patients followed for two years or more, 55 per cent survived for this period or longer. These figures are almost identical with those reported by Thompson³ for a series of cases of malignant lesions of the prostate gland in which the patients were treated by transurethral resection and irradiation at the Clinic in the years 1924 to 1941, inclusive. It should be pointed out, however, that the two groups are not strictly comparable for several reasons. The special group of 326 patients in the series reported by Thompson were followed for a minimum of five years whereas our patients were followed for a shorter time. Furthermore, in the cases reported by Thompson, the period of survival was computed from the time the diagnosis was proved by transurethral resection whereas in our group the period of survival was computed from the date of orchectomy, which in many cases was not performed for a considerable time after transurethral resection. In some cases, the diagnosis had been made and resection may have been performed months or years before orchectomy.

CASES IN WHICH METASTASIS HAD OCCURRED BEFORE OPERATION

In 167 of the 219 cases there was clinical roentgenographic or chemical evidence of metastasis when orchectomy was performed. The survival rates, in relation to the length of time of the follow up study, are shown in table 1. Of the 167 patients, fifty four were alive and 113 were dead as of May, 1945. The fifty four patients who were alive had lived an average of thirty months since orchectomy. Table 2 shows the number of months in trimesters that these patients have remained alive. The 113 patients who were dead had lived an average of 15.4 months. Table 2 shows the number of months in trimesters that elapsed between orchectomy and the time of the patients' deaths. It will be noticed that 33 (20 per cent) of the patients who showed evidence of metastasis died within the first nine months after operation. In other words, 87 per cent of our patients lived for nine months after orchectomy whereas, in the series of cases reported by Bumpus,² 33 per cent of the patients lived for the same period. It should be pointed out, however, that Bumpus made his report in 1926 and it is our impression that the prognosis in cases of carcinoma of the prostate in which metastasis has occurred has improved in recent years even before the use of orchectomy in these cases.

Relief of Pain—An important phase in this problem is the relief of metastatic pain by bilateral orchectomy, both as regards the degree

TABLE 1—PERIOD OF SURVIVAL

Period of Survival Yrs *	All Cases				Cases in Which Metastasis Had Occurred			Cases in Which Metastasis Had Not Occurred		
	Patients Operated On	Patients Who Lived Beyond Indicated Period		Patients Operated On	Patients Who Lived Beyond Indicated Period		Patients Operated On	Patients Who Lived Beyond Indicated Period		Per Cent
		Number	Per Cent		Number	Per Cent		Number	Per Cent	
1 or more	219	170	78	167	119	71	52	51	98	
2 or more	179	99	55	130	58	45	49	41	84	
3 or more	61	23	38	50	15	30	11	8	73	

* Measured to the date of inquiry, which was as of April 1, 1945. The patients who survived two years, for instance, were operated on prior to April 1, 1943.

of relief and the duration of such relief. Furthermore, the question arises as to whether the prognosis is better in cases in which the patients receive complete relief of pain by orchiectomy. In an effort to study these problems we asked the patients who had suffered from metastatic pain prior to orchiectomy to state, in percentage form the degree of relief they secured. Of the 167 patients who had evidences

TABLE 2 — PERIOD OF SURVIVAL IN CASES IN WHICH METASTATIC LESIONS WERE PRESENT WHEN ORCHIECTOMY WAS PERFORMED

Period of Survival Mos	In 51 Cases in Which Patients Were Living at Time of Inquiry	In 113 Cases in Which Patients were Dead at Time of Inquiry
0-3		7*
4-6		15
7-9		11
10-12		17
13-15		11
16-18	3	7
19-21	4	10
22-24	9	10
25-27	7	8
28-30	5	5
31-33	5	4
34-36	8	2
37-39	7	1
40-42	6	
43-45		1

* Excluding one patient who died in the hospital

of metastasis prior to orchiectomy, 132 complained of metastatic pain. Table 3 shows the degree of relief that these patients secured from the operation. The results are classified further on the basis of the degree of malignancy of the prostate according to Broders' method of grading (in cases in which such data were available). It may be seen that eighty-four patients secured either complete or great relief from metastatic pain by orchiectomy. It can be stated, therefore, that more

TABLE 3.—RICH OF PAIN IN 132 CASES IN WHICH ANALGESIC EFFORTS WERE PRESENT WHEN ORCHESTRA WAS PERFORMED

Grade of Malignancy*	Cases	Results not Recorded	Degree of Relief from Pain				No Relief
			100 Per Cent	75 Per Cent	50 Per Cent	25 Per Cent	
1 and 2	29	—	17	4	2	4	2
3 and 4	47	5	32	10	5	1	4
Unknown	56	2	24	10	9	3	11
Total	132	7	70	24	16	8	17

* Determined by the method of Broders

than 60 per cent of the patients who had metastatic pain obtained great immediate relief by orchectomy. Furthermore it appears that the degree of malignancy is not a factor in the immediate results ob-

TABLE 4—DURATION OF RELIEF FROM PAIN IN 60 CASES IN WHICH METASTATIC LESIONS WERE PRESENT WHEN ORCHECTOMY WAS PERFORMED

Duration of Relief from Pain Mos	Cases
4-6	6
7-9	6
10-12	10
13-15	5
16-18	4
19-21	1
22-24	2
25-27	1
28-30	3
31-33	1
Relief still present	17
Unknown	4
Total	60

TABLE 5—GRADE OF MALIGNANCY AND INTERVAL OF TIME SINCE ORCHECTOMY IN 17 CASES IN WHICH METASTATIC PAIN IS STILL ABSENT

Interval Since Operation Mos	Grade of Malignancy			Cases
	1 and 2	3 and 4	Unknown	
16-18			2	2
19-21	2			2
22-24	1	1		2
25-27		1		1
28-30	3			3
31-33		2		2
34-36		1	1	2
37-39	1			1
40-42			2	2
Total	7	5	5	17

tained. These findings are similar to those which we have reported previously.²

In our last report we stated that the pain recurred in twenty eight (47 per cent) of the sixty cases in which it had been relieved com-

TABLE 6—RELATION BETWEEN PERIOD OF SURVIVAL AND RELIEF OF PAIN

Period After Operation, Yrs *	Patients with Metastatic Lesions			Patients Who Obtained Complete Relief from Pain			Patients Who Obtained Only Incomplete Relief or No Relief†		
	Patients Operated On	Lived Beyond Indicated Period		Patients Operated On	Lived Beyond Indicated Period		Patients Operated On	Lived Beyond Indicated Period	
		Number	Per Cent		Number	Per Cent		Number	Per Cent
1 or more	167	119	71	60	53	88	107	66	62
2 or more	130	58	45	15	32	71	85	26	31
3 or more	50	15	30	16	6	38	34	9	26

* Measured to the date of inquiry, which was as of April 1, 1945. The patients who survived two years, for instance, were operated on prior to April 1, 1943.

† Includes patients who did not have any pain prior to orchiectomy.

signs of metastasis before death. Metastatic lesions usually appeared ten to fifteen months after orchectomy.

INCIDENCE OF RECURRENCE OF URINARY OBSTRUCTION AFTER TRANSURETHRAL RESECTION AND ORCHECTOMY

The role of orchectomy in the prevention of symptoms of recurrent urinary obstruction after transurethral resection has been a subject of interest. In our previous report we called attention to the fact that, during the years 1937 to 1941 inclusive, 517 patients who had carcinoma of the prostate gland underwent transurethral resection at the Clinic. Twenty-two (4 per cent) of these patients returned within the first year because of recurrent obstruction which required further resection while eleven patients (2 per cent) returned for the same reason during the second year after resection. All patients in this group had been followed for two or more years. It is impossible to compare this group with our group in which only 179 of the 219 patients have been followed two or more years. From the data available however, interesting deductions can be made. Of all patients in our group who underwent simultaneous transurethral resection and orchectomy, only one patient (0.4 per cent) returned within the first year because of recurrent obstruction. This patient returned to the Clinic twelve months after operation. Three other patients returned because of a recurrence of urinary obstruction in the second year after the operation. In these three cases the resection was repeated. Transurethral resection had to be repeated in four other cases. In these cases the original transurethral resection had been performed more than two years before orchectomy. In two cases in which transurethral resection had not been performed previously, the patients returned to the Clinic for resection seventeen and twenty-two months respectively after orchectomy was performed. These findings appear to indicate that orchectomy tends to prevent the recurrence of urinary obstruction after transurethral resection.

SUMMARY AND CONCLUSIONS

The patients in this series of cases have not been followed for a sufficient length of time to permit us to state whether orchectomy increases the period of survival more than does transurethral resection alone or in conjunction with irradiation in cases of carcinoma of the prostate gland. This question cannot be answered until the patients have been followed for a longer period and the results compared with those obtained by transurethral resection in a similar group of cases. We hope to report the results of such a study in the future.

The three year survival rate was 30 per cent in cases in which metastatic lesions were present when orchectomy was performed. In

cases in which there was no evidence of metastasis when orcheectomy was performed, the three year survival rate was 73 per cent

Although we cannot yet be sure whether castration will prolong life in cases of carcinoma of the prostate gland, we are sure of its therapeutic value for pain caused by metastasis of carcinoma of the prostate. Our study indicates that at least 60 per cent of patients who have metastatic pain will immediately obtain dramatic relief by orcheectomy. Unfortunately, in approximately one half of these cases the pain may be expected to recur within four to fifteen months.

At the present time, we are performing orcheectomy only in cases of carcinoma of the prostate gland with metastasis in which the metastatic lesions are producing symptoms. Further study of the results of this operation may bring about a change in our method of treating patients who have carcinoma of the prostate gland.

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occurrence of carcinoma, when other factors may produce an operative mortality rate which is considerably higher, particularly if the complete hysterectomy is being performed by a surgeon not skilled in its execution

For many years erosions and lacerations with infection, eversion of the mucosa and polyps have been considered to have a definite relationship in the induction of carcinoma. About the only evidence at hand to support this is the higher incidence of carcinoma when these conditions are present but they cannot be the dominant factor since a high percentage of carcinomas of the cervix are seen in nulliparas.

Recently, intensive pathologic studies have been made routinely of cervixes which have been removed at total hysterectomy for lesions other than those of the cervix in order to see if early malignant lesions of the cervix were being overlooked. The findings suggest that epithelial hyperplasia and noninvasive carcinoma exist in a larger number of cases than had been thought previously. In the Clinic biopsies of cervixes which are at all suspicious and which are not obviously carcinomatous are taken routinely. A surprisingly larger number of cases of carcinoma-in-situ were found than were found before this routine was adopted. However, it must be remembered that these cervixes were not what are considered to be normal. Against this evidence, which would indicate that the cervix should be removed, is the fact that although throughout this country and in the British Isles, supracervical hysterectomy is performed often, statistics from all available sources reveal that carcinoma of the cervical stump occurs in only about 0.2 per cent of cases in which supracervical hysterectomy was performed. However, in many cases in which supracervical hysterectomy is performed, either the endocervix is destroyed with the actual cautery or conization is performed preceding hysterectomy. The use of these procedures should be recommended on the evidence at hand if the surgeon for definite reasons does not wish to perform total hysterectomy. For the same reason supracervical hysterectomy should not be performed with complete disregard of the condition of the cervix as has been done ill advisedly in some cases of large fibroids or chronic pelvic inflammation. This is mentioned because gynecologic surgeons often are asked to remove an edematous, cystic, infected and often lacerated cervical stump. At the Clinic we remove about thirty such stumps each year. In addition some of them had become partly or completely prolapsed because of faulty cervical support at the time of hysterectomy.

When abdominal hysterectomy is being considered for any condition other than carcinoma of the fundus or adnexa, which in itself requires complete hysterectomy, the state of the cervix must be observed carefully and it should be determined specifically at that time whether or not the cervix should be removed completely. The evi-

dence seems sufficient that the cervix always should be inspected for disease of any type if abdominal hysterectomy is considered and that if the cervix is diseased complete hysterectomy should be performed or local treatment should be given at time of operation and supracervical hysterectomy performed. Let me state it another way. A definitely diseased cervix is an indication for complete hysterectomy if hysterectomy is being considered for any other purpose. The operation should be performed by those who are familiar with the technic. In the hands of those who are not familiar with the procedure, local treatment to the cervix such as actual cautery or conization should be given and should be followed by supracervical hysterectomy.

Mobility of the Cervix—The mobility of the cervix is an important consideration in complete abdominal hysterectomy. Certain postoperative results such as vaginal shortening and fixation of the vaginal vault must be avoided regardless of the marital or sexual status of the patient. If the lesion is malignant these results need not be considered as factors. In the nulliparous patient if the vagina is of normal depth and the cervix is normal it is preferable not to perform complete hysterectomy especially if the patient is still young and single because the vagina remains normal after supracervical hysterectomy. Also depths of vaginas vary considerably and some have an extremely short anterior wall and no anterior fornix. Occasionally the posterior fornix and either of the lateral angles are scarred or fixed from old lacerations so that complete hysterectomy would result in more fixation and perhaps shortening of the vagina. Once this occurs it never can be remedied and therefore the possibility of development of such a condition and the reasons for the choice of the type of operation which is proposed should be explained carefully to both husband and wife. Fixation and shortening may seem like irrelevant conditions but nevertheless they are real and serious problems.

The cervixes of most multiparas will be more mobile as a rule than others unless fixed by intrapelvic disease. This mobility results from separation or stretching of the normal attached pelvic fascia. If stress has been severe enough various degrees of cystocele, rectocele and prolapse of the uterus will be present. Many operations have been devised in an attempt to support the retained cervix more adequately instead of performing total hysterectomy. Most of these operations are faulty unless they are combined with somewhat more extensive vaginal plastic repair. I am certain that a poorly supported cervix is much more uncomfortable than a well supported vaginal vault.

When a clamp across the vagina is utilized in complete hysterectomy shortening of the vagina will result almost invariably or fixation will result from trauma. In the usual case in which the cervix is moderately mobile and anterior and posterior fornices are redundant the vagina can actually be lengthened by utilizing all of the vaginal

wall instead of leaving some of it attached to the cervix. The purpose of placing clamps across the vagina is to prevent contamination of the pelvic cavity. Too much stress has been laid on the probability of infection extending into the abdomen from the opened vagina. If the vagina is cleansed well preceding hysterectomy little infection will come from this source. As a matter of fact, the amount of infection has been found to be so insignificant that some gynecologists now recommend leaving the vaginal vault open for more adequate drainage following total hysterectomy or Wertheim hysterectomy.

When a mobile cervix has been removed at complete hysterectomy, it is much simpler and sounder on an anatomic basis to reconstruct the vaginal vault than it would be to support the cervix adequately if subtotal hysterectomy were performed. The principal supporting structures of the cervix are the cardinal ligaments, which are the fibrous, thickened portions of the pelvic fascia on either side of the cervix opposite the internal os. These ligaments must be divided completely in order to remove the cervix. Then they are shortened and reattached to the angles of the vagina. If these reattached ligaments are then pulled laterally or toward the bony wall of the pelvis, which is the point of origin of the ligaments, the vagina actually will be elevated or lengthened and adequately supported. Many moderate cystoceles can be corrected sufficiently by this method also.

The moderately mobile cervix and attached vaginal walls are good indications for complete abdominal hysterectomy when hysterectomy is indicated and adequate support of the vagina is desired.

CONDITIONS IN WHICH COMPLETE ABDOMINAL HYSTERECTOMY IS INDICATED

Carcinoma of Cervix.—Malignant lesions of the cervix are not regarded generally as an indication for complete abdominal hysterectomy. A few types of carcinomas, however, may be treated surgically rather than with radium. Carcinoma-in-situ or noninvasive carcinoma either of high or low grade of malignancy is one of these types. These patients all can be cured by total hysterectomy without removal of the adnexa or the subsequent treatment with radium. How long these lesions remain noninvasive is unknown, but it is probably many months. This is an excellent reason for recommending that biopsies of the cervix be made as an office procedure and that regular or periodic examinations be made especially if the patient is young.

It is possible that some stage 1 carcinomas (lesion confined to cervix) would be cured by total abdominal hysterectomy, but the probabilities of invasion of the lymph nodes are too great to do other than a radical or Wertheim hysterectomy. This operation includes the complete removal of not only the uterus but the parametrium, obturator and iliac lymph nodes and adnexa. The principles of this opera-

tion are sound and the results have compared favorably with those for carcinomatous lesions elsewhere that have been treated surgically. The mortality and morbidity have been gradually reduced so that now they are within satisfactory limits. The operative mortality rate following total abdominal hysterectomy for carcinoma of the fundus varies between 3 and 5 per cent. Recently more than fifty Wertheim hysterectomies have been performed without a single death and little morbidity. A statistical report of operability, glandular involvement and results of surgical treatment eventually should be made just as has been done for carcinoma of the breast. Also the influence of diabetes and tuberculosis on the surgical results should be studied. At the present it seems most likely that this procedure will be limited to stage 1 and some stage 2 carcinomas. Gynecologists as a group are showing a greater interest in this operation because it now appears to be more effective in the treatment of some cervical carcinomas than it previously was considered to be. Complete abdominal hysterectomy is indicated definitely in cases of carcinoma in situ and stage 1 carcinomas and in some cases of stage 2 carcinomas.

Malignant Lesions of Fundus and Adnexa—Complete abdominal hysterectomy always has been indicated in cases of operable malignant lesions of the fundus and adnexa. In treatment of carcinoma of the fundus two schools of thought exist regarding preliminary radiation treatment. It is agreed that the lesion should be removed surgically unless conditions other than the malignancy definitely would contraindicate surgical intervention. Total abdominal hysterectomy would not be performed in cases of severe cardiac disease or general arteriosclerosis with hypertension in which the patient perhaps already has some residual of one or two vascular accidents. Advanced age usually is considered to increase the risk of operation greatly for many patients have lived beyond their life expectancy.

The results of preliminary treatment with radium followed in six weeks by total abdominal hysterectomy and also the results of total abdominal hysterectomy without preliminary treatment with radium have been published and can be compared easily. We follow the latter procedure at the Clinic because we feel that if a lesion is operable the sooner it is removed surgically the better the result will be. However in some cases of the more malignant lesions the vaginal vault is treated with radium preoperatively and some treatment with roentgen rays is given postoperatively.

Malignant lesions of the adnexa are so quiescent in their development that they are the most serious of all malignant lesions of the female generative tract. The incidence of bilateral involvement is so high that conservative operation is never justified. This is true for malignant cysts as well as solid carcinomas of the ovary. The chances of cure by radical operation after the lesion has extended to the

peritoneum or omentum are poor indeed. Also, 10 per cent of these lesions when first seen already have extended to the uterus.

It is obvious, therefore, if the patient is to have the best possible prognosis from one of the most silent and serious diseases that complete abdominal hysterectomy should be performed and both adnexa should be removed, particularly if the lesions do not give evidence of distant metastasis.

Benign Intrapelvic Lesions.—In cases of benign intrapelvic lesions, per se, it is often necessary to perform complete abdominal hysterectomy. The condition of the cervix and its mobility are usually the determining points. Chronic pelvic inflammation is one condition about which there is considerable discussion as to whether complete hysterectomy is indicated. It has been our experience that in some cases it is indicated and in some it is much wiser to perform supracervical hysterectomy. For example, occasionally the induration in the parametrium is so firm and the cervix so fixed that it becomes too dangerous a procedure to effect removal. Too, repeated drainages through the posterior cul de sac may result in a similar fixation.

Generally speaking a better physiologic result is obtained if the cervix is removed when pelvic inflammatory disease is present, because it always is infected in various degrees. At times postoperative cellulitis will ensue if it is left and some of these cervixes subsequently will have to be removed through the vagina to prevent vaginal discharge. Some urethritis and trigonitis and discomfort in the low part of the back are attributed directly to an infected cervical stump. Rarely is any systemic disturbance present.

Pyometra is best treated by complete hysterectomy, especially if it occurs subsequent to treatment with radium. In this same category is chronic endocervicitis associated with chronic endometritis which is seen more commonly after repeated induced abortions.

TECHNICAL DIFFICULTIES

Certain technical difficulties in performing complete abdominal hysterectomy should be stressed. The most common complication is injury to the bladder or a ureter. In order to avoid injury of the bladder, one should carefully mobilize it where it is reflected from the uterus. It is identified easily by its extreme vascularity. Incising the bladder is not a serious accident but the incision should be closed immediately. I mention this because sometimes the accident is not recognized and vesicovaginal fistula occurs immediately postoperatively. The delayed fistula which occurs between the fifth and tenth day after operation is caused by a suture which passes into the vesical cavity and then sloughs through. The vesical wall is caught by the suture which closes the vaginal vault and this is another reason why I feel that a clamp never should be placed across the vagina.

The next anatomic difficulty has to do with the ureter. The only place in the entire ureter that is fixed or rigid is at the ureterovesical juncture. About 25 cm. above this point the uterine artery crosses the

This results in a ureterovaginal fistula or a stricture of the ureter. This accident can be avoided if under these conditions the peritoneum of the broad ligament is opened and the uterine artery is ligated back near its source from the internal iliac artery. The ureter then should be identified and elevated to be sure it has not been injured.

This accident also may occur during the carrying out of Wertheim hysterectomy which requires the removal of all the parametrium. Here the bladder and ureters must be elevated and some branches of the vesical artery must be ligated. The important point is not to interfere too much with the blood supply of the ureter or here again it will slough and produce a fistula.

Concluding I would state that there are very definite indications for performing complete abdominal hysterectomy. Some of the most pertinent ones I have discussed. Also I do not believe it should be recommended as a routine procedure when abdominal hysterectomy is indicated but the type of hysterectomy should be determined by consideration of the individual case and the operation chosen should be the one that will give the maximum of comfort and the minimum of complications.

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THE SURGICAL CLINICS of NORTH AMERICA

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SYMPOSIUM ON ASEPTIC SURGICAL TECHNIC AND ITS APPLICATION TO THORACIC SURGERY

HISTORICAL ASPECTS OF ASEPTIC SURGICAL TECHNIC

JOSIAH C. TRENT, M.D., F.A.C.S.*

In this section, devoted to aseptic surgical technic and its application to thoracic surgery, it is quite appropriate to include an account of the development of the modern aseptic ritual, for, in an attempt made at Duke Hospital to control "unexplained" infections in operative wounds of the thorax, an important contribution to our present technic, an effective and practicable method of sterilizing the air in the operating room, was devised¹⁵

THE PREANTISEPTIC ERA

Occasionally in the history of a science we come upon a discovery so revolutionary that it serves as a point of division in that science between the ancient and the modern. In surgery, the discovery of the antiseptic principle was of such significance that the centuries of tradition and experience which preceded it appear as nothing when compared with the rapid advances made in the decades which followed. It is difficult for us, in possession of the benefits of asepsis, to visualize the terrible and tragic conditions prevailing only eighty years ago, in the preantiseptic era. Erysipelas, pyemia, septicemia, hospital gangrene and tetanus were never absent from the wards, and every operative wound was infected. It is small wonder that "pure" creamy

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Some of the material in this essay has appeared in *Thumbnail Sketches of Eminent Physicians: The Evolution of the Aseptic Principle in Surgery*, North Carolina Med J, 6 1936

pus, without the tell-tale odor of incipient gangrene, was referred to as laudable. Because of sepsis, little progress had been made in extending the scope of, and indications for, surgery. Abdominal surgery was hardly thought of, the only operation performed on the thorax was empyema drainage, the cranial cavity and spinal cord were virtually unexplored. Amputation, lithotomy, vascular surgery and the drainage of abscesses made up the bulk of a surgeon's practice. Sur-



Fig. 434—The Preantiseptic Era. Amputation of an arm under strict "septic" conditions (From Laurenz Heister's *Chirurgie*, Dritte Auflage, Nürnberg, 1731)

geal results were judged by the mortality statistics of amputation. 25 per cent was considered a "very low" rate, 50 per cent was a more normal figure. The very multitude of the wound dressings that were advocated through the centuries, from the simple wine dressings of the ancient Greeks to the pus promoting dressings of the middle ages—a pernicious practice which continued well into the nineteenth century—is evidence enough that none was entirely satisfactory, though

some were mildly antiseptic in character; nor could a satisfactory method be devised until the cause of wound suppuration was understood.

Some progress toward the acquiring of such an understanding was made in the study of puerperal fever, a disease peculiarly adapted to observations on its transmissibility. John Burton⁸ first suggested, in 1751, that puerperal fever might be conveyed to a patient by an outside agency. Charles White of Manchester,⁴⁴ in 1773, stressed the similarity between puerperal fever and surgical fever; he advocated, in dealing with the former, such precautionary measures as complete isolation of infected patients, rigid cleanliness (asepsis) and thorough ventilation of the delivery room, and the use of antiseptic douches. The first positive statement as to the contagious nature of the disease was made by Alexander Hamilton¹⁴ in 1781, when he described puerperal fever as "remarkably contagious" and capable of being conveyed from one patient to another. The ensuing decades saw repetitions of this assertion by various physicians, with increasing emphasis on the function of attendants and doctors as carriers of the fever; prophylactic measures similar to those of White were recommended by many. The doctrine was an unattractive one, however, since physicians in general did not care to think of themselves as bearers of disease, and it received no wide acceptance. Not until 1843 was the issue brought squarely before the medical profession in America. In that year Oliver Wendell Holmes published his famous essay on "The Contagiousness of Puerperal Fever,"¹⁶ maintaining that the "*disease known as Puerperal Fever is so far contagious as to be frequently carried from patient to patient by physicians and nurses.*" This doctrine and the preventative measures which Holmes advocated were not original with him, but his article had the merit of stirring up a controversy which aroused wide attention. Beginning in 1847, a similar debate was excited in Europe by the work of Ignaz Philipp Semmelweis.⁴⁰ In the face of acrimonious opposition, this great Hungarian demonstrated the contagiousness of puerperal fever and showed that its transmission could be prevented by such simple measures as washing the hands in an antiseptic solution before examining, assisting or in any way touching a patient.

ADVANCE IN BACTERIOLOGY

Despite such anticipatory stirrings, the complete realization of the aseptic principle could come only with an understanding of the etiology of wound infections, and this knowledge waited upon the development of the science of bacteriology. The long foreground of that science, from Leeuwenhoek's great discoveries until the mid-nineteenth century, need not concern us here. Throughout this period, as during preceding ages, men postulated as the causative agents of

disease various miasmas, vapors, gases and animalcules. The germ theory of disease developed but slowly, although a great number of observations on the origin and cause of infectious diseases wound suppuration and putrefaction appeared during the late eighteenth and early nineteenth centuries.

In 1822, Olhvier²⁶ produced experimental hospital gangrene by autoinfection, and in 1822-1823 Gaspard,²¹ at the suggestion of François Magendie, made experimental studies in pyemia, injecting putrid fluids and other substances into various animals. In 1835 with his demonstration of the parasitic nature of the muscardine disease of silkworms Bressi laid the foundation of the doctrine of pathogenic microorganisms. A year later Franz Schulze²⁷ demonstrated that no putrefaction occurred in boiled infusions if the air was drawn through acid or alkali, and Theodor Schwann²⁸ carried out similar experiments using heat rather than chemicals to sterilize the air. Schwann²⁹ and Cagniard Latour³ presented evidence, in 1837, to prove that the fermentation of sugar was due not to oxygen as was commonly believed, but to the growth in the solution of a yeast, *Torula cerevisiae*. These discoveries, and others of like import, received scant attention from a bigoted scientific world, dominated by armchair logic, but the time was ripe for genius to integrate these isolated facts and demonstrate their significance.

At this most opportune time, Louis Pasteur, an obscure French chemist whose work had dealt chiefly with crystalloids and their polarizing properties began to encounter in certain industrial fermentations exceptions to the laws of correlation between crystals and rotary power laws which he had previously found invariable. He gradually shifted his field of interest from pure chemistry to biology. Since he knew from previous observations that life alone is capable of creating full fledged new dissymmetries, he began careful researches into the vital principle of fermentation, presenting the results of his study to the Société des Sciences de Lille in August of 1857.²⁹ He concluded

It is now my opinion as the result of the knowledge I have gained on this subject that whoever will judge impartially of the results of this work and those which I shall publish in the future³⁰ will recognize with me that fermentation is correlative with life with the organization of globules (yeast) not the death or putrefaction of these globules.*

From these studies it was but a step to questioning the origin of these "globules," and Pasteur soon became absorbed in an effort to solve once and for all the celebrated question of spontaneous generation an effort intimately connected with his desire to arrive at a

* The doctrine which Pasteur here rejected was a widely accepted one forcefully advocated by the great German chemist, Justus Liebig.

knowledge of the causes of putrid and contagious diseases. By 1862, with a series of simple but masterful experiments, he had demolished the theory of spontaneous generation.³¹

THE ANTISEPTIC PRINCIPLE

In 1865 Dr Thomas Anderson, Professor of Chemistry at the University of Glasgow, who was familiar with Pasteur's work, called it to the attention of the Professor of Surgery at the same institution, Joseph Lister. Lister had already given much thought to inflammation and suppuration and had patiently sought for a means of assuring the healing of wounds by primary intention. The missing link in his search was supplied by the knowledge he derived from Pasteur's writings: there he learned that putrefaction was in fact fermentation, that it was caused by the growth of microorganisms carried to the wound on particles of dust floating in the air, and that it was possible to free the air of these germs by heat, filtration or chemical action. Of these three germ destroying methods, Lister chose the chemical as the most practicable. Fortunately, the first antiseptic which he tried was carbolic acid (German creosote), he had heard of its recent successful use in the disinfection of sewage at Carlisle, and Dr Anderson supplied him with a sample of the chemical. In March, 1865, at the Glasgow Royal Infirmary, Lister for the first time employed the undiluted chemical in a case of compound fracture, the case was improperly managed, and the attempt unsuccessful. The next experiment, on August 12, 1865, was undertaken in a case of compound fracture of the tibia. The wound was treated first with lint soaked in carbolic acid, later with dressings of carbolic acid diluted in water and in olive oil. This simple technic, based on Pasteur's teaching that putrefaction is caused by bacteria coming from the air, met with complete success. Bacteria which had gained access to the wound were first destroyed, then by the application of antiseptic dressings the entry of new bacteria was prevented until healing had occurred.

The use of antiseptics in putrefactive diseases was certainly not original with Lister. Many early surgeons employed dressings containing alcohol and various balsams. Sir John Pringle,³⁴ in 1752, reported a series of experiments in which he had tested the effects of a variety of substances in delaying putrefaction. Pringle's work was continued by Madame d'Arconville¹ who, in 1766, reported the effectiveness of mercurial salts among other substances, in the prevention of putrefactive changes. In 1764 the German surgeon Bilguer⁴ described his method of treating wounds, which consisted essentially in filling the recesses of the wound with antiseptics and placing on the surface a piece of lint dipped in an antiseptic solution. Alcohol, glycerin, chlorine and its various compounds, iodine and other chemicals were variously recommended in the early nineteenth century.

French surgeons and chemists became much interested in the disinfectant properties of coal tar and conducted an extensive inquiry into its usefulness. One result of this inquiry was the work of Jules Lemaire, who studied first the antiseptic properties of coal tar combined with tincture of saponine, and later those of carbolic acid, publishing his report on the latter in 1863.²¹ In the same year Enrico Bottini, then at Novara Hospital later a professor at Pavia, began to investigate the value of carbolic acid as a disinfectant of the operative field, his findings were published in 1866²² when Lister's work was still in its experimental stages. Both Lemaire and Bottini knew of, and accepted

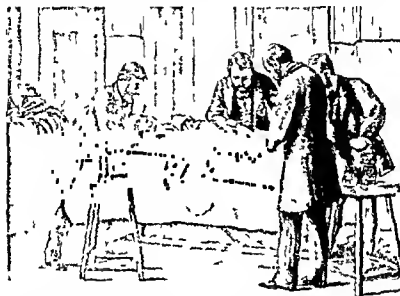


Fig. 435—The Antiseptic Method. A drawing showing strict observance of the method developed by Lister. (From W. Watson Cheyne, *Antiseptic Surgery: Its Principles, Practice and Results*. London, 1882.)

the germ theory of disease, both preceded Lister in the use of carbolic acid to destroy germs. Nearly a year before Lister came to recognize the significance of Pasteur's work in relation to surgery, Spencer Wells⁴³ discussed Pasteur's doctrines before the British Medical Association and described the antiseptic experiments of Polli of Milan, who had

by mouth to neutralize

of these men or of the other pioneers who might be named, with the establishment of antiseptics? Wells offered only a brilliant hypothesis, Lemaire and Bottini offered only an effective antiseptic. Lister alone brought forward and

maintained a scientific principle in accordance with which methods of procedure might be devised. For him carbolic acid was simply a means to an end, for Lemaire, Bottini and the others the particular antiseptic which each employed was an end in itself, was itself the most important factor in wound dealing. Lister never allowed his real purpose, the destruction of the pathogenic organisms which he knew to be present everywhere, to be obscured by blind devotion to established details of technique to chemical substances or to pieces of apparatus.

In 1867 Lister reported the then amazing results of his new method of wound therapy in a paper entitled, "On a New Method of Treating Compound Fracture, Abscess, Etc., with Observations on the Conditions of Suppuration." It is significant that in the title he speaks of a "method of treatment and does not specify carbolic acid. Several months later, on August 9, 1867, in addressing the British Medical Association at Dublin. On the Antiseptic Principle in the Practice of Surgery,²³ Lister remarked:

To prevent the occurrence of suppuration with all its attendant risks was an object manifestly desirable but till lately apparently unattainable since it seemed hopeless to attempt to exclude the oxygen which was universally regarded as the agent by which putrefaction was effected * but when it had been shown by the researches of Pasteur that the septic property of the atmosphere depended not on the oxygen or any gaseous constituent but on minute organisms suspended in it which owed their energy to their vitality it occurred to me that decomposition in the injured part might be avoided without excluding the air by applying as a dressing some material capable of destroying the life of the floating particles.

Upon this principle I have based a practice.

After further careful experiments and reasoning Lister was able to set down the factors necessary for *per primum* healing of clean wounds: (1) the germs must be destroyed on the patient's skin, on the surgeon's hands, on the instruments used, and on everything sur-

* The belief that the air or one of its components had a harmful effect upon wounds was long in force and various methods were devised to prevent suppuration by excluding the air. To combat the cooling and drying effects of air Jules Guyot in 1835 and later recommended incubation of the wounded part at a temperature of about 36° C. The subcutaneous method of surgery grew up as a result of the fear of air. Delacroix, Anel and Abernethy were pioneers in the technique. Delpsch in 1816 performed the first subcutaneous tenotomy. Dupuytren, Stromeyer, Diefenbach and Jules Guérin contributed greatly to the development of the method. Various methods of occlusion were proposed. Guérin (1839) favored covering the wound with goldbeaters' skin. William Rhind (1842) and Laugier (1844) recommended gum arabic. Chaissagnac (1844) used layers of diachylon plaster. Guérin (1866) and Mussionneuve (1867) proposed pumping the air away from the wound by the use of complicated apparatuses. Still other approaches to the problem were suggested: the substitution of various gases for air, a technique on which Demarquay and Leconte experimented extensively, reporting in 1866 in favor of carbonic acid gas, the immersion of wounds in a warm water bath, a method principally advocated by Stromeyer and Langenbeck.

rounding the area of operation (2) germs must be prevented from entering the wound during operation (3) germs must be prevented from spreading into the wound after operation. This revolutionary concept was difficult for the profession to grasp and it met with considerable opposition. Many insisted on calling Lister's method the "carbolic acid treatment" and completely lost sight of the underlying principle necessary for its proper application. It had its champions, however, particularly on the continent where it was apparently first introduced in 1869 by Mathias Sætorph, Professor of Clinical Surgery in the University of Copenhagen who visited Glasgow in that year and observed Lister's technique. The practice was adopted by such eminent surgeons as Richard von Volkmann at Halle in 1872, Nussbaum at Munich in 1874 and Esmarch at Kiel in 1875. Volkmann practiced exact Listerism with brilliant results and became one of the strongest and most outspoken advocates of the system. A similar position was taken by Just Lucas Championnière in France. In America, where the disciples of Lister and Pasteur were few, the introduction of the antiseptic system was only slowly accomplished.

ASEPSIS

As the antiseptic principle spread, surgeons everywhere sought for newer and safer methods of accomplishing the same end. Lister himself constantly emphasized the point that the means employed were of small significance as long as the desired end—the exclusion of germs from the wound—was gained. Even his vehement opponent, Lawson Tait of the soap and boiling water school, was actually the advocate of a somewhat primitive aseptic technique. The great German surgeon Billroth accepted Lister's principle while questioning his means and stated that he would regard the antiseptic system with suspicion as long as it depended on carbolic acid; he like many other surgeons had had fatal cases of poisoning from carbolic acid.⁶

In spite of the brilliant work of Pasteur in the promulgation of the germ theory of disease and the development of Lister's remarkable antiseptic treatment of wounds, utter confusion existed among medical men as to the causative organism or organisms of surgical sepsis. Bacteriology as a science was still undeveloped and pure cultures of bacteria were unobtainable. In retrospect, in view of the meager knowledge then available concerning the infective agents the results achieved by Lister seem all the more remarkable. Before further progress was possible in the development of asepsis, it was necessary for the bacteriologists to overtake the surgeons who had far outdistanced them.

The modern concept of wound infection began with the publication of Robert Koch's great work on the etiology of traumatic infective diseases¹⁸ in which he reported six different kinds of surgical

infections artificially produced in animals and clearly demonstrated that each was due to a different microorganism which bred true in pure culture. Probably Koch's greatest contribution, however, was the poured plate method of obtaining bacteria in pure culture.¹⁹ Also, with Gaffky and Loeffler in 1881,²⁰ he designed the first steam sterilizer, an important advance which was not utilized in the aseptic technic for several years.

While bacteriologists were providing the knowledge necessary for intelligent procedure in wound therapy, surgeons themselves were assiduously seeking for simpler means of accomplishing their goal of primary wound healing. Lister himself made great contributions to the development of asepsis. In 1881, at the Seventh International Medical Congress, held in London, during the symposium on "The Causes of Failure in the Primary Healing of Wounds," he presented the results of further experiments, which showed that blood serum itself possessed bactericidal properties and that actual closure of a wound was not necessary if the wound were filled with blood clot, properly covered, and left alone.²¹ In 1883 he recorded an "Antiseptic Operation without Antiseptic Contact"¹² and by 1887 he had abandoned the antiseptic spray.*

As the antiseptic system spread, constant improvements in technic were made. The transition from the "wet" or antiseptic treatment of wounds to the "dry" or aseptic method, however, was largely due to the work of two German surgeons, Gustav Neuber of Kiel and Ernst von Bergmann of Berlin. Neuber, long an assistant to Esmarch and a devoted experimenter in the antiseptic technic, came to the realization that no further progress could be made until caustic antiseptics could be dispensed with. In 1884 he built a private hospital in Kiel for the express purpose of carrying out his new methods of asepsis, and two years later he published the details of his technic,²² the main

* Early in his experiments in a rather crude attempt to sterilize the air, Lister had introduced the carbolic acid spray, which during the operation filled the air around the operating table with a mist of carbolic acid. Lister first publicly recommended this apparatus on August 10, 1871, at the Plymouth meeting of the British Medical Association (*Brit M J*, 2:225-233 [Aug.] 1871). Besides working a hardship on both surgeon and patient, the spray failed to produce the desired results. Its utility was first assailed by Bruns of Tübingen in 1880 (*Fortschr. Med.*, 17:609, 1880), and many surgeons abandoned it. A Canadian surgeon, MacEwen,

found Lister using no spray,

but reported

the old method

as a kind of fetish.

He is a thorough Listerite of

ritual is orthodox and complete. I saw him do an abdominal section and although

standing some feet off was drenched from head to foot with the spray and felt the

chilling effects of the carbolic acid for some days afterwards. (Shepherd, F. J.

Notes of a Visit to Some of the Anatomical Schools and Surgical Clinics of Europe

in 1887, *Canad M J* 14:56-65 [Jan.] 1924.)

features of which were (1) separation of "clean" and "dirty" cases (2) sterilization of the air entering the operating room by heat and filtration (3) cleansing the entire body of the patient and the operative site with mercuric bichloride, (4) washing of the hands and arms of the operating team with soap and water, (5) sterilization of instruments and drapes by boiling (6) closure of wounds without drainage. The ritual of asepsis thus begun was improved during the latter part of the eighties in the clinic of Ernst von Bergmann, a native of Riga, Russia. Later Professor of Surgery at Berlin. His technique as recorded by Schimmelbusch³⁶ differed essentially from Neuber's in that nascent steam according to the method of Koch²⁰ or steam under pressure was used to sterilize the dressings and drapes which had been placed in metal drums of the kind in general use today.

The universal adoption of the aseptic principle in surgery rapidly followed upon the elaboration of the technical details by von Bergmann. In spite of the effectiveness of this technique in preventing most infections, there remained several possible sources of wound contamination, namely the operator's bare hands, droplets from the nose and throat and the patient's own skin.*

RUBBER GLOVES

Many surgeons were quick to realize that even with prolonged scrubbing and improved antiseptics it was impossible to sterilize the hands, but many years passed before an effective method for screening bare hands from the operative wound was devised. Through the example and influence of William Stewart Halsted, Professor of Surgery at the Johns Hopkins Hospital, the use of rubber gloves as a means of preventing wound contamination was at length introduced. Rubber gloves were first worn in Halsted's clinic as early as 1889† to protect from antiseptics the hands of certain members of the staff: the nurse who squeezed out sponges kept in bichloride of mercury solution and the assistant who passed instruments which had been immersed in carbolic acid.¹³ As the staff became accustomed to the gloves, their use became more general and the emphasis was gradually shifted from protection of the operating personnel to protection

* This still remains a problem, although not a serious one. See in this volume Lovell Durward L. *Preoperative Skin Preparation with Reference to Surface Bacteria, Contaminants and Resident Flora*.

† There were isolated instances of their use prior to this date in Europe. For example, F. J. J. J. writes: "When an assistant to Professor Verneuil in 1888 I saw Jalaguier who came there to operate, the skin of his hands being very sensitive to antiseptics, he had formed the habit of operating in rubber gloves equipped with cuffs reaching up the forearm." (*Aperçu historique de l'antisepsie et de l'asepsie*, Presse méd. 36, 2^e sem. 1195 [Sept.] 1928.)

of the patient In 1895 Hunter Robb then resident gynecologist of Johns Hopkins wrote

Rubber gloves are not employed so widely as they should be It is probable that the chances of infection would be very much diminished if the assistants were required to wear them at operations since they can be rendered absolutely sterile which is not necessarily true of the skin of the hands Their use by the operator himself would also facilitate the performance of a great deal of minor work without any inconvenience therefrom⁵⁵



Fig 436 —The Use of Rubber Gloves in the new surgical amphitheatre at Johns Young Mitchell and Bloodgood appear in photographs showing an entire operating team wearing rubber gloves Notice the absence of masks (Reproduced through the courtesy of the Johns Hopkins Press from W G MacCallum *William Stewart Halsted Surgeon*, Baltimore and London 1930)

Halsted himself at this time occasionally used gloves in operating on clean joints⁶ but it appears that the first person to wear them invariably while operating was Dr Joseph Colt Bloodgood Halsted's house surgeon who began the practice in December of 1896 In 1913 at the insistence of his staff Halsted finally published a resume of the

operative technic which had evolved in his clinic¹³ In speaking of the introduction of rubber gloves he said

Operating in gloves was an evolution rather than an inspiration or happy thought and it is remarkable that during four or five years when as operator I wore them only occasionally we could have been so blind as not to perceive the necessity for wearing them invariably at the operating table *

MASKS

Lister based his antiseptic system on the belief that most pathogenic bacteria were airborne, later it was learned that direct contact is a more important factor in their transmission, and after the publication of Tyndall's findings in 1881⁴² concerning the relatively harmless character of most airborne germs, surgeons came to regard the danger of airborne infection as negligible However, occasional cases of sepsis occurred in spite of the most rigid adherence to the ritual of asepsis, and surgeons began to look for other sources of infection Pasteur⁴³ and Sternberg⁴⁴ demonstrated in 1881 that the pneumococcus could be carried in healthy throats, and it came to be recognized that the human mouth is a perfect breeding place for all types of bacteria The fact that exhaled air contains far fewer bacteria than inhaled air misled most observers for a time

In 1897 Carl Flugge, then at Breslau, published an account of his investigations on droplet infection⁴⁵ Flugge not only proved that the human nose, throat and mouth might contain pathogenic bacteria, but he also demonstrated that all persons in speaking laughing coughing and sneezing scattered from their mouths a fine spray of germ laden saliva He concluded his account by pointing out the importance of his findings to the surgeon Because of the renewal of interest in airborne infections in recent years, I shall quote at length

proceed from the operator from the assisting personnel, and from the spectators (page 223)

I do not doubt that by far the greatest part of wound infection is established through contact and that surgeons have with good reason given far more considera

* The objections customarily advanced against the use of gloves were summarized by Nicholas Senn writing in 1901 Perhaps one of the best proofs that all known methods of hand sterilization have their defects is the present quite extensive use of rubber gloves advocated by Halsted Mikuliez Fenger and other surgeons It is easy to foresee that this practise will never become general even in the clinical amphitheatres The rubber gloves impair the delicate tactile sense of the fingers are expensive easily torn and furnish a soothing poultice for the conscience when the surgeon fails to prepare his hands properly (Practical Surgery, Philadelphia and London 1901, p 172)

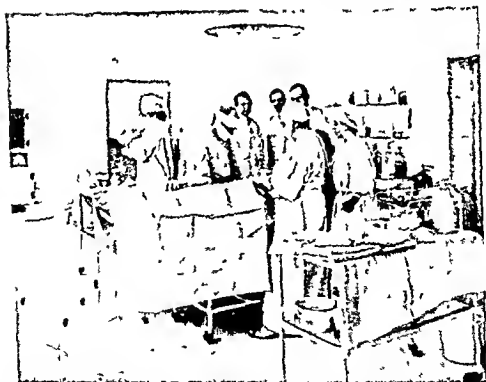


Fig 437.—The Introduction of Surgical Masks The second edition of Berkeley Moynihan's *Abdominal Operations* (Philadelphia and London, 1906) contained one of the earliest textbook recommendations for the use of masks during operations, the cry, the
 in which the universal use of masks in the operating room became customary (All three pictures are reproduced through the courtesy of W B Saunders Company)

tion to this side of the question than to airborne infection. But one dares not ignore the danger nevertheless which is set up for operative wounds by the excreted droplets scattered into the air and there floating so easily and transported so far and the possibility must be taken into account that many abnormalities in the progress of operative wounds which are protected against contact are to be traced back to this invisible mode of infection.

The extent of this contamination is then of interest in determining the precise dangers which threaten the fresh operative wound but since knowledge of such questions can be gained only through experience I have asked my esteemed colleague Professor Mikulicz to be permitted to confirm the practical significance of these proceedings experimentally studied by me through joint investigation into the sources of the failures of modern asepsis (page 224)

Mikulicz at Flugge's suggestion began testing various methods of reducing the dangers of droplet infection. In 1897 he published his results, in an article principally devoted to advocating the use of cotton rather than rubber gloves.²⁴ He wrote

I was first made aware of the significance of the danger of the dissemination of pathogenic bacteria from the mouth and nose through Herr Flugge who had established experimentally that even by tranquil speech bacteria can be scattered from the mouth in very fine fluid drops into surrounding space. We have indeed at Breslau the custom of hardly speaking at all at operations necessary communications are easily conveyed through signs with the hands. But a word must be said here and there. If the surgeon has a cold which causes him to sneeze at inconvenient moments then he must according to Flugge be entirely excluded from operating. All these dangers will be wholly avoided if one wears during the operation a mouth bandage covering the mouth and also the nostrils. A piece of mull serves the purpose and can be used also to cover the beard. We have operated already quite a long time with mouth bandages at all aseptic operations we breathe through them as easily as a lady wears a veil on the street. The mask is of course sterilized (page 716)

Mikulicz despite the early satisfaction he expressed regarding his mull mouth bandages was apparently not entirely satisfied with either the protection they afforded or the comfort. He asked one of his colleagues W. Hubener to check on the efficiency of the mask and to improve its design. Hubener published his results in 1898.²⁷ He demonstrated that the simple cloth mask used by Mikulicz by no means afforded a satisfactory frame-
ces—carry

Mikulicz's efforts must have received little attention from surgeons at large however for Paul Berger a French surgeon writing in 1899²⁸ of his own experiments with masks modeled on Mikulicz's concluded pessimistically that he expected his communication to receive little more attention from his colleagues than the report of Mikulicz had from German surgeons. In 1901 John Poland spoke of Mikulicz's use of masks as a somewhat ridiculous and extreme measure.²⁹ From 1900 on however numerous articles appeared advocating various modifica-

tions of these masks. A multitude of designs were proposed, all to the same purpose; to keep out of the operative wound bacteria coming from the nose and throat. Today gauze face masks which cover the nose and mouth are worn routinely by all individuals in the operating room.

ULTRAVIOLET IRRADIATION OF AIR

Although today's masks do serve as a filter for the coarser droplets from the upper respiratory tract, it can easily be shown that they are not completely effective in stopping the fine spray generated by talk-

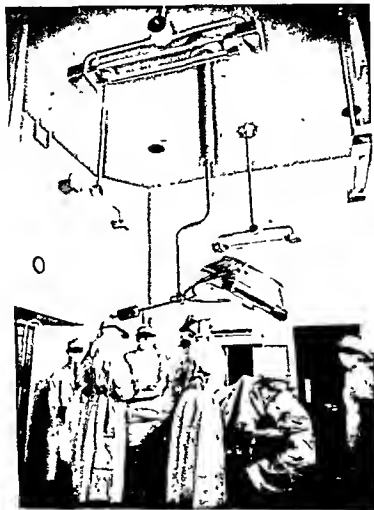


Fig 438 —Modern Asepsis. An operation performed under bactericidal ultraviolet irradiation at the Duke Hospital, Durham, North Carolina

ing, coughing or sneezing. It was this fact which led Deryl Hart of Duke University to devise a rapid, practicable method of sterilizing the air in the operating room in an attempt to control those infections which occurred in spite of rigid aseptic precautions.¹⁵ By irradiating

the air with special short wave ultraviolet light he was able to reduce the number of bacteria in the air to such a point that they no longer constituted a hazard*.

The per primam healing of wounds depends upon many factors other than strict aseptic precautions, and not the least of these are accurate hemostasis careful handling of tissues and the use of fine suture material. However, with the best of technic and the proper observance of all requirements of asepsis, there are still many "unexplained" wound infections. These can be reduced to a minimum by the judicious employment of this last addition to our aseptic armamentarium sterilization of the air by ultraviolet irradiation.

With the introduction of penicillin and other powerful antibiotic agents the surgeon has been given a new means of combating infection. It is inevitable that this extremely effective weapon will afford a perfect windfall in many cases of infection in clean wounds, for the surgeon who grows careless in his technic. It should be remembered, however, that the principles of asepsis and good surgery still go hand in hand and no drug has yet been discovered which can make up for a deficiency in aseptic practice.

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PREOPERATIVE SKIN PREPARATION WITH REFERENCE TO SURFACE BACTERIA CONTAMINANTS AND RESIDENT FLORA

DURWARD L. LOVELL, M D *

MODERN aseptic technic theoretically aims at complete eradication of bacteria so that not a single organism can reach the wound at any time during and after the operation. Under such conditions healing would take place aseptically. Such perfection in actual practice is almost impossible to attain but it is our constant goal to minimize contamination of wounds as much as possible. The modern plan of maintaining such a technic is an elaborate one and requires attention to detail and careful observation to see that no loopholes admit any of offending organism from many possible sources of contamination. Such a plan is like a chain which is only as strong as the weakest link. Sterilization of the skin of the patient seems to be the weakest link in the chain of sterile technic, because no antiseptic yet devised is able to destroy all of the bacteria in the skin. For this reason the skin is a constant source of contamination of clean operative wounds and precautions must be taken to prevent serious infections from this source. The purpose of this paper is to make clear the value of preoperative preparation of the skin and to point out methods whereby contamination and infection of operative wounds by these bacteria may be minimized.

Classification and Location of Skin Bacteria—The bacteria of the skin are classified into two main groups: the transient, which may include any organism that comes in contact with the skin, and the resident, which includes bacteria that are normal inhabitants of the skin. The transient bacteria are usually located on the surface embedded in the horny fat, beneath the desquamating superficial cells of the horny layer, and in the crypts and crevices. The number and kind of organisms that make up the transient flora depend on the cleanliness of the individual and his contacts with a variety of sources of contamination including the surrounding air. This transient group contains the more pathogenic types of bacteria including *Staphylococcus aureus*, *streptococcus*, *Escherichia coli*, *Bacillus proteus* and

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B. pyocyaneus They frequently cause serious wound infections when they are allowed to enter clean wounds and find conditions favorable for growth

In contrast to the superficial location of the transient bacteria, some of the resident flora are situated in the deeper parts of the skin. In a previous publication,¹ it was shown that the resident bacteria are lo-

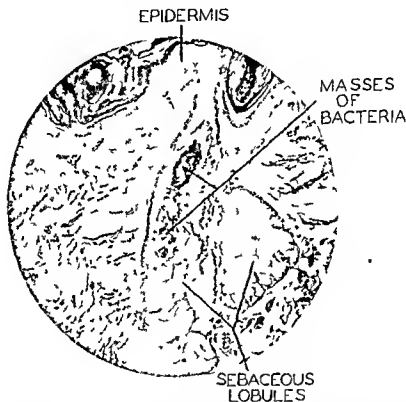


Fig 439—Photomicrograph showing a section of skin removed from the female breast and incubated for six hours. The surface of the skin was cleaned with iodine and alcohol before removal and the section was stained to show the bacteria. Large masses of bacteria are shown extending deep into the sebaceous gland and far below the skin surface. (By permission of Surgery, Gynecology and Obstetrics.)

cated on the surface embedded in the horny fat, in the crypts and crevices, hair follicles and sebaceous glands. A study of sections of skin which had previously been incubated for six hours, in order to locate the bacteria more readily in regard to their position and depth showed resident bacteria located very deep in the pilonidal follicles embedded in the sebaceous material (Figs 439 and 440). The number of bacteria in the pilonidal follicles varied greatly. In some in

stances no organisms were found in others they had increased sufficiently to fill completely the upper part of the duct (Fig 440) Careful study of the sweat glands in many sections failed to show any bacteria in the excretory ducts in the coiled portions as they pass through the epidermis or in the secreting tubules All of the bacteria were located outside the body since they were not seen within or between living cells of the epidermis or the cells lining the pilonidal

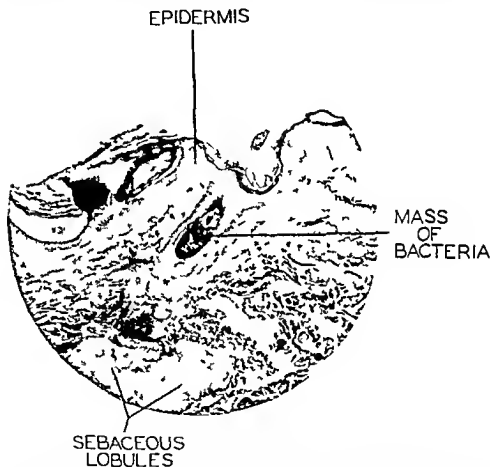


Fig 440 —Photomicrograph showing a section of skin removed from the female breast and incubated for six hours The duct of the sebaceous gland is cut in cross section and shows a mass of bacteria which fills the lumen of the ducts (By permission of Surgery Gynecology and Obstetrics)

follicles The resident flora probably remains fairly constant since over a long period of time the organisms comprising this group have acquired the ability to live and multiply in surroundings that are unfavorable for the growth of other bacteria The resident bacteria usually include *Staphylococcus albus* and *Staph. citreus* but it is thought that other organisms may become residents in the skin after prolonged contact with them

Changes in the Bacterial Flora Following Surgical Cleansing Methods.—Price² has shown that scrubbing with brush, soap and water removes readily the transient flora of bacteria, but far more slowly the resident flora. Most of the transient organisms of the skin are quite superficial and can be removed by thorough mechanical and chemical cleansing. Mechanical cleansing is more efficient than chemical cleansing for removing surface bacteria, because the dirt, horny fat and other foreign material must be removed before the antiseptic can reach organisms located beneath the desquamating epithelium of the epidermis. Inasmuch as the resident bacteria are located so far below the surface, they cannot be removed by mechanical means. Sebum is a highly insoluble substance and all of it cannot be removed by soap, water or chemicals without injuring the skin (Fig 439). Any chemical solution that would sterilize the skin would necessarily have an enormous penetrating power. Experiments have shown¹ that the generally used antiseptics do not have sufficient penetrating power to reach the bacteria that are located deep in the hair follicles and sebaceous glands.

After thorough mechanical and chemical cleansing negative swab cultures can sometimes be obtained from the skin surface because most of the transient bacteria have been removed. The resident bacteria rise to the surface and multiply after a short time, however, especially if the skin becomes moist and the surface tension is increased. Cultures taken from the skin surface at the end of operations are always positive for bacterial growth. These bacteria consist of large numbers of *Staphylococcus albus* and *Staph. citreus* and occasionally smaller numbers of the more pathogenic types. The number of transient organisms that can be recovered from the skin surface at the end of the operation depends on the thoroughness with which mechanical and chemical cleansing was performed. Preoperative skin preparation, therefore, removes most of the surface bacteria but many of the resident bacteria remain in the hair follicles and sebaceous glands and serve as an important source of contamination.

The Role of the Resident Bacteria in Contamination and Infection of Wounds.—In a previous publication,³ it was shown that bacteria gain entrance to the wound during most clean operations. A few organisms are carried into the incision with the skin knife as a result of cutting into contaminated hair follicles and sebaceous glands. Some of them possibly gain entrance as a result of contaminated perspiration flowing over the skin edges. This may occur regardless of the fact that towels are closely applied. Cultures taken from the wound immediately after the skin incision is made are usually positive for bacterial growth.³ Similar cultures taken during the latter part of the operation are positive for a greater number of bacteria. This increase in their number during the time of the operation occurs even

though bactericidal radiant energy is used to minimize contamination from the air. This is probably due to the fact that the resident bacteria gaining entrance to the wound by transplantation with the skin knife multiply during the time of the operation. The greater number of these bacteria are of the *Staphylococcus albus* and *Staph. citreus* variety. They belong to the resident flora and generally do not cause serious wound infections unless they are present in large numbers or the wound is left in such a condition as to encourage their growth. Very few of the more pathogenic types of bacteria will gain entrance to clean operative wounds if the skin is properly prepared and adequate precautions are taken to prevent this during the time of the operation.

Although the presence of a relatively large number of resident bacteria may not cause gross infection with suppuration in a wound, they should not be disregarded. They may cause prolonged elevation of the postoperative temperature and excessive pain, redness and induration of the wound. In the presence of avitaminosis and other nutritional, systemic or local conditions, these organisms may be factors in delaying healing, thereby predisposing to disruption of the wound and postoperative hernia. Stitch abscesses or excessive scarring may be the result of infection caused by these bacteria. Frequently they cause chronic low grade infection around subcutaneous suture material, leading to draining sinuses; and in many instances, the sutures must be removed before proper healing takes place.

Plan of Minimizing Contamination of the Operative Wound by Skin Bacteria.—The high probability of the entrance of bacteria into every operative wound should be a constant challenge to reduce such contamination. Unless the operation is urgent, the presence of even minor infections in the field of the proposed incision contraindicates operation until the lesion is healed. Incisions that are to be reopened during second stage operations should be carefully examined for stitch abscesses, adhesive dermatitis and low grade infection in the deeper part of the wound.

The transient flora of bacteria can be removed only by careful preoperative preparation of the skin. The day before operation a large area in the region of the proposed incision should be washed thoroughly with soap and water, shaved closely, and then cleansed with soap and water, 70 per cent alcohol and ether in locations where these do not burn. Just before the operation the skin should again be washed thoroughly with soap and water, 70 per cent alcohol and ether, and covered with a sterile towel. After the patient has been anesthetized, chemical cleansing should be performed to further reduce the number of bacteria on the surface. Numerous good antiseptics are available but 3.5 per cent iodine is probably used more frequently than any other chemical on the patient's skin preparatory to operation. Two

layers of iodine should be applied and then removed with 70 per cent alcohol to prevent blistering. Following chemical cleansing all of the skin except a small area where the incision is to be made should be covered by sterile towels which are held in place with clips.

Inasmuch as all of the resident bacteria cannot be removed by modern methods of preoperative preparation the skin should be considered as contaminated at all times. The skin surface should not be touched with the gloved hand or instruments that are to be used during the remainder of the procedure. The knife employed to make the initial incision should be discarded because it has been contaminated by cutting through pilonidal follicles containing bacteria. All exposed skin should then be covered with sterile towels and fastened in place with clips, care being taken not to leave the edges of the incision uncovered. These towels should be left in place until the wound is closed to the subcutaneous fascia. At this time the skin surface should be considered as being more contaminated than at the time the original incision was made because during the operative time the resident bacteria rise to the surface and multiply. This is best combated by changing the towels and cleaning the skin surface with the antiseptic solution before the superficial sutures are inserted. This reduces the bacterial contamination of the subcutaneous tissues and results in fewer bacteria about the subcutaneous and cutaneous sutures.

Factors that Minimize Infection of the Operative Wound by Skin Bacteria—Since contamination of the wound cannot be entirely prevented the presence of these bacteria make it imperative that the tissues be left in the best possible condition for combating their growth. When only a few bacteria gain entrance to the wound they do not interfere with healing because with good surgical operative technic the tissues can easily cope with them without infection. Emphasis must be placed therefore on the fact that these bacteria become important in regard to gross infection only when their multiplication is aided and abetted by faults of operative technic. Such features of technic as gentle handling of tissues, careful hemostasis, avoidance of tension in placing sutures and obliteration of dead space should never be overlooked. Other factors such as the unnecessary use of the cautery and ligation with strangulation of large amounts of tissue will create conditions favorable for the growth of bacteria in the wound. Stitch abscesses are best avoided by the additional precaution of early removal of the suture and avoidance of tension.

SUMMARY

Sterilization of the skin seems to be the weakest link in the chain of sterile technic. Modern antiseptics fail to remove all the bacteria in the skin because they are located too deep in the hair follicles and sebaceous glands. Contamination of wounds from this source may be

minimized, but with our present knowledge it cannot be entirely prevented. This contamination can be minimized only by thorough mechanical and chemical cleansing of the skin and careful attention to operative technic. Bacteria gain entrance to most clean operative wounds and the presence of these organisms makes it imperative that the tissues be left in the best possible condition for combating their growth.

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THE USE OF METHYL METHACRYLATE PLOMBAGE IN THE SURGICAL TREATMENT OF PULMONARY TUBERCULOSIS

DAVID A. WILSON, M.D.*

SINCE extrapleural pneumolysis was introduced by Tuffier in 1891 phthisiologists and surgeons interested in the treatment of pulmonary tuberculosis have been seeking a nonirritating material which could be used as a plombage to maintain the lung in a collapsed state. Many agents including fat, paraffin, hydrostearolein, gauze, rubber, muscle and air have been utilized in the past with poor results.

In 1938 a new synthetic plastic material was introduced for use in dental prosthesis (Geiler). This plastic material known chemically as methyl methacrylate represented the result of many years of exhaustive chemical research. It had been used for several years prior to this time by commercial plastic manufacturing companies, marketed under the trade names of lucite, plexiglas, vitarilic and others. Methyl methacrylate is an acrylic resin manufactured under exacting chemical and physical conditions from acetone, hydrogen cyanide and methyl alcohol in the presence of sulfuric acid. The polymerized form is a clear, light weight solid which softens at 105° C, and can easily be molded into any desired shape. Its characteristic property is its high tensile strength. It is relatively inert. It is not affected by weak acids or alkalis. It absorbs very little water without changing its chemical composition and does not appear to deteriorate like other plastic materials which have been implanted into the human body.

In January 1940 Kleinschmidt studied the effects of methyl methacrylate used to repair cranial defects in experimental animals. He found remarkably little inflammatory reaction and no foreign body response characteristic of other foreign agents used in the human body. This work has been confirmed by others. During the first few days the methyl methacrylate plate is surrounded by a small amount of serum which rapidly becomes organized forming a thin film of hyaline connective tissue. Rarely does sufficient serum accumulate around the implants to require aspiration. This fact has been stressed

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by Gurdjian and his co workers, by Kahn, and Woolf and Walker who have used methyl methacrylate successfully in human cranioplasties Woolf and Walker described one patient with an infected wound which cleared up with penicillin and local treatment without removal of the plate Kahn also believes that this material is so inert that it may be used in the primary repair of perforating wounds of the head

Spealman, Main, Haag and Larson have studied the effects of methyl methacrylate implanted into the peritoneal cavity The material was allowed to remain nine months before autopsy of the animals was performed Encapsulation of the particles by a thin film of hyaline connective tissue without the formation of adhesions was noted

Methyl methacrylate has been used clinically to repair cranial defects (Zander, Gurdjian, Webster and Brown) and to study the brain and pial circulation (Sheldon, Pudenz, Restarski and Craig) It has been used successfully in reconstructive surgery as a substitute for cartilage for the correction of facial deformities (Penhale, Brown) and in arthroplasties for osteo arthritis (Harmon) It was first used experimentally to secure a pulmonary collapse by Wilson and Baker in 1944 The effects of this plastic material inserted into the pleural cavity of thirty rats and into the extrapleural space of ten dogs was studied A collapse of individual lobes was secured in approximately half of the rats by inserting into the pleural cavity a portion of methyl methacrylate premolded into the shape of the lobe to be collapsed In the other half of the rats the pleural cavity was filled with small $\frac{1}{4}$ inch methyl methacrylate balls All of the animals tolerated the methyl methacrylate well and showed no systemic reaction X rays taken at frequent intervals following operation showed little evidence of pleural effusion Autopsies performed at intervals of from two days to eight months showed only slight inflammatory changes and no foreign body reaction The balls were surrounded by a thin serum immediately following the operation, and the pleura showed minimal thickening and infiltration with eosinophils In the majority of the animals the methyl methacrylate became encapsulated by a thin layer of hyaline connective tissue In ten of the rats the methyl methacrylate implants were still free in the pleural cavity eight months after operation

The methyl methacrylate implanted into the extrapleural space of the two dogs became encapsulated by a dense layer of hyaline connective tissue The adjacent lung showed little evidence of reaction except atelectasis as a result of compression

ADVANTAGES

Methyl methacrylate, in addition to being nonirritating to the tissues, possesses certain definite advantages over other foreign materials

which have been advocated for use as a plombage. The material is light weight and a large quantity can be introduced without danger of penetrating the pleura or thin walled cavities. It is radiolucid and does not interfere with the interpretation of roentgenograms. Both these factors are of great importance in thoracic surgery.

For use in patients the methyl methacrylate was molded into solid and hollow balls 1 inch in diameter. This makes possible the filling of varying sized pockets at operation. As many as sixty balls have been utilized in a single patient without ill effects. As the air between the balls is absorbed serum accumulates around the balls. This serum later becomes organized into hyaline connective tissue maintaining the lung permanently in a collapsed state.

A nonirritating plombage material permits the successful utilization of the operation extrapleural pneumolysis. Introduced by Tuffier in 1891 this procedure consists of stripping the lung along with the parietal pleura away from the chest wall through a small anterior or posterior incision. The advantages of this operation over other major surgical procedures used in the treatment of pulmonary tuberculosis are (1) Operation can be performed under local anesthesia (2) There is little or no shock or blood loss and transfusions are rarely required (3) The involved area of lung can be selectively collapsed thus preserving the function of normal lung tissue. This makes possible the successful treatment of patients with bilateral apical cavities, low vital capacity and the like (4) There is no mediastinal shifting following operation. Expectoration of sputum is easy and there is little danger of bronchogenic spread (5) The postoperative management is relatively easy (6) There is no chest deformity or scoliosis.

INDICATIONS

The indications for extrapleural plombage with methyl methacrylate are limited since the use of this material in thoracic surgery is still in the experimental stage. The indications, however, are much broader than those established for extrapleural pneumothorax. All patients in which this procedure has been used have been under a strict sanatorium regimen and pneumothorax has been attempted and found to be unsuccessful. Recent spread does not constitute the same contraindication to operation as it does for thoracoplasty. Many patients not suitable for either thoracoplasty or resection can be successfully treated by this method.

Those patients considered most suitable for operation are (1) Patients with bilateral apical cavities (2) Patients with unilateral cavities and infiltration in the opposite lung (3) Patients in which the pulmonary tuberculosis is complicated by asthma, diabetes, heart disease or low vital capacity (4) Patients of advanced age who because of their general physical condition are not candidates for major

surgical procedures (5) Patients in whom thoracoplasty has been performed without successful closure of the cavity Extrapleural stripping of the apex of the collapsed lung and plombage in these patients

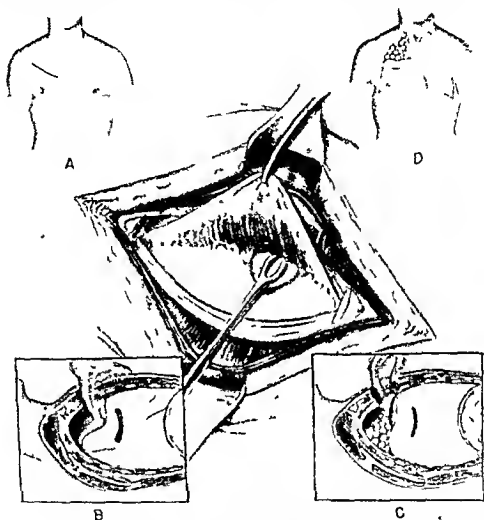


Fig 441—Operative technique The extrapleural space is developed by blunt dissection A lighted retractor is used for the deeper part of the dissection A Incision is made over the second rib and cartilage The pectoralis major muscle is split and retracted The incision is made through the anterior periosteum A section of rib and cartilage is resected B The extrapleural space is developed by blunt dissection or compressed against the rib C The extrapleural space is filled with methyl methacrylate balls after which the section of rib is replaced and the periosteum is approximated to the rib D, Composite drawing of balls in extrapleural space

offers a single stage procedure which can be performed under local anesthesia with little or no shock and with a good chance of cavity closure (6) Patients with a thoracoplasty on one side who have

developed a cavity in the opposite apex (7) Patients with cavities in the basal portion of the lung In these patients extrapleural pneumolysis and plombage of the lower lobe permits a selective collapse and preserves the function of the uninvolved upper lobe

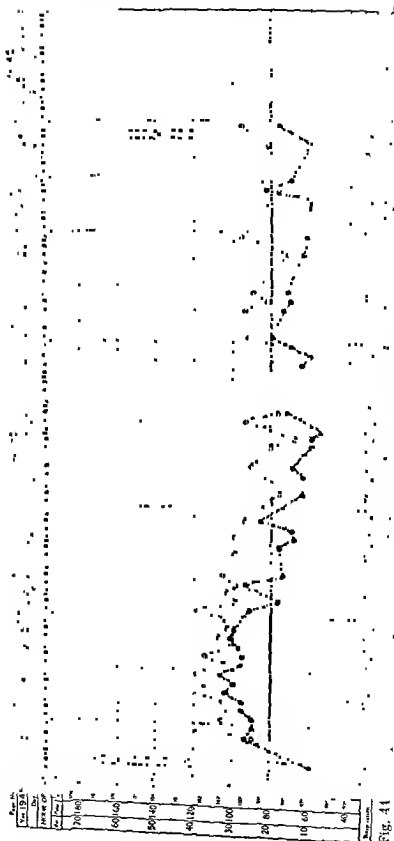
OPERATIVE TECHNIC

Preoperatively the patient is given 0.1 gm. of sodium pentobarbital the morning of operation and 16 mg. of morphine one half hour before operation. An anterior or a posterior approach may be used (Fig. 441). I prefer the anterior approach because access to the extrapleural space is easier and because the patient is more comfortable in the supine position during operation. After the skin has been prepared the area overlying the second rib and cartilage is infiltrated with 2 per cent procaine and the incision is made down to and parallel to the rib and cartilage. The intercostal nerves are blocked with 2 per cent procaine. The pectoralis major muscle is split along the course of its fibers and a 4 inch segment of rib and cartilage resected aperiosteally. The rib segment is carefully saved. A longitudinal incision is made through the posterior periosteal bed and the extrapleural space is carefully developed by blunt dissection. Finger dissection is much safer than instrumental dissection. As the space is developed a small sponge on a clamp is substituted for the finger. A lighted retractor is indispensable. The entire apex is mobilized down to the hilum of the lung and the space filled with methyl methacrylate balls. The rib segment is resutured into place and the periosteum is reapproximated around the rib margin to hold the balls in the extrapleural space. The pectoralis major muscle is reapproximated and the skin closed with interrupted silk sutures. Additional anesthesia is rarely needed after the extrapleural space is entered.

COMMENT

Extrapleural pneumolysis from a theoretical standpoint is based on sound surgical principles. Adequate collapse of the lung can be secured by this method as with intrapleural pneumothorax or thoracoplasty. Entrance into the extrapleural space probably occurs during the course of most thoracoplasties and is attended by little if any increase in danger to the patient. Many present day thoracic surgeons routinely combine extrapleural apicolysis with thoracoplasty.

At the present time over twenty five patients with far advanced pulmonary tuberculosis have been operated upon using methyl methacrylate plombage to maintain a collapse of the lung developed by extrapleural pneumolysis. Two patients have had bilateral apicolysis, two patients with a thoracoplasty on one side have had an apicolysis performed for a cavity in the apex of the other lung, four patients have had an uncollapsed apical cavity beneath an old thoracoplasty.



— temperature; ···· pulse.

one patient has had a cavity in the left lower lobe in the costovertebral angle. With few exceptions, all of the patients have had complications which contraindicated thoracoplasty or pulmonary resection. The results have been sufficiently gratifying to continue the operation upon an increasing number of patients and to broaden the indications to include many patients who are candidates for thoracoplasty but who refuse thoracoplasty because of the operative risk and deformity.

Contrary to the experience following thoracoplasty and pulmonary resection, the postoperative management of patients with extrapleural pneumolysis and methyl methacrylate plombage has been relatively easy. Since operation is performed under local anesthesia the cough reflex is not abolished, and expectoration is easy. There is no mediastinal shifting and bronchogenic spread has not been encountered in any of the patients following the use of this procedure.

All of the patients have been operated upon in operating rooms equipped with bactericidal radiation, and all of the patients have been given penicillin postoperatively. Infection in the extrapleural space which previously discouraged the use of plombage has not been encountered with the use of methyl methacrylate and with the above precautions. A small amount of blood tinged fluid accumulates around the balls as the air is absorbed. Aspiration of this fluid is rarely required and the danger of infection from repeated thoracentesis is nil. The average postoperative temperature has been 38.2°C , on the second or third postoperative days, with a return to normal by the fifth or sixth postoperative days (Fig. 442). Most of the patients complain of a feeling of pressure in the operative site and notice the clicking together of the balls during the first three or four days. These complaints have never been troublesome. The average postoperative hospital stay has been ten to fourteen days.

COMPLICATIONS

Complications of extrapleural pneumolysis and plombage with methyl methacrylate may be divided into two groups, namely, those arising as a result of the operative procedure, and those attributed to the use of methyl methacrylate. This former group includes (1) accidental rupture into the lung or thin walled cavity, (2) hemorrhage into the extrapleural space, (3) formation of a bronchopleural fistula, (4) tuberculous or secondary infection in the extrapleural space, and (5) cardiac failure due to diminution of the pulmonary circulatory bed.

Accidental rupture into a thin walled cavity adjacent to the pleura during extrapleural pneumolysis has been recorded many times. It is an error in surgical technic and may occur in the best of hands. Im-

mediate open drainage or cavernostomy is imperative either with or without thoracoplasty. Such an accident frequently results in a fatality. It constitutes a real danger in all extrapleural operations. This complication has not been encountered in my personal experience.

Massive hemorrhage, a troublesome complication in extrapleural pneumothorax, has not been encountered in association with methyl methacrylate plombage. Large vessels running between the chest wall and the lung are carefully coagulated by means of a diathermy during operation. Transfusions have not been required in any of the patients.

Formation of a bronchopleural fistula, a complication which so frequently occurred with extrapleural pneumothorax and with paraffin plombage, has not been encountered in this series. Methyl methacrylate, unlike paraffin, is relatively inert in the extrapleural space. It does not predispose to foreign body reaction and inflammatory changes which is so frequently the basis for formation of bronchopleural fistulas.

Neither tuberculous nor secondary infection of the extrapleural space has occurred in this series of cases. This is attributed to the use of bactericidal radiation and the liberal use of penicillin during and following operation.

Cardiac failure due to reduction in the pulmonary circulatory bed constitutes a real risk with extrapleural pneumolysis and plombage. Many of the patients upon whom this operation is performed already have their circulatory capacity reduced to a dangerously low level. In this series there has been one delayed death as a result of cardiac failure due to diminution of the pulmonary circulatory bed.

The second group of complications is that which might be attributed to the methyl methacrylate. Experimental human toxicity studies of methyl methacrylate were conducted by Speelman, Main, Haag and Larson using the patch test method on fifty medical students. No reactions whatsoever were observed when the polymerized form was used. Similar studies performed on experimental animals also led them to conclude that methyl methacrylate is nontoxic when introduced into the body. In our series only one reaction which could be attributed to the methyl methacrylate has been observed. This reaction occurred in the form of a generalized urticaria in a patient who had no previous history of atopic manifestations. The urticaria appeared on the tenth postoperative day and lasted three days. There has been no recurrence.

SUMMARY

Methyl methacrylate is an acrylic plastic which fulfills all the essential criteria of an ideal plombage material. It is solid at ordinary temperature but softens when heated to 105° C. It is light in weight but has a high tensile strength. It is radiolucid and does not obscure the lung detail. It is nonirritating to the human body.

Extrapleural pneumolysis and plombage with methyl methacrylate is still in the experimental stage. It has been used in the treatment of



Fig 443—A Preoperative and, B, postoperative roentgenograms of chest of 59 year old woman with far advanced pulmonary tuberculosis treated by extrapleural pneumolysis and plombage



Fig 444—Roentgenograms of chest of a 34 year old man with cavity in left apex occurring two years after right two stage thoracoplasty. Roentgenograms (A) before and (B) after patient was treated successfully by extrapleural pneumolysis and plombage

over twenty five patients with pulmonary tuberculosis. Most of these patients have had complications which contraindicated thoracoplasty

or pulmonary resection. The results in these patients have been sufficiently gratifying to continue its use in many less complicated cases of pulmonary tuberculosis.

The use of this procedure has certain advantages over other present-day surgical methods of collapse therapy. It is a single-stage operation which can be performed under local anesthesia with relatively little operative risk. The collapse is permanent. There is no postoperative mediastinal shifting, expectoration is easy, and the danger of bronchogenic spread is greatly diminished. The postoperative management



Fig. 445.—Roentgenogram of chest of 54 year old man with bilateral apical cavities (A) before and (B) after being treated by means of bilateral extrapleural pneumolysis and plombage with methyl methacrylate balls.

is easy. Patients with bilateral apical cavities, patients with basal cavities, patients with low vital capacity, cardiac disease, and advanced age, and patients with residual cavities beneath a thoracoplasty can be successfully treated by this method.

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CONTROL OF SO-CALLED "UNEXPLAINED INFECTIONS" IN SURGICAL WOUNDS, WITH PARTICULAR REFERENCE TO THORACIC SURGERY

DERYL HART, M D, F A C S * AND JAMES D MOON, M D †

WITH the introduction of antiseptic and then aseptic technique in surgery, rapid strides were made in extending operative treatment to all parts of the body

In his earlier work on antiseptic methods Lister gave great consideration to the bacteria in the air as a cause of wound infections, but later realized that contact contaminations played by far the major role in wound infections of that day. As a result of this better understanding of the relative dangers of contact versus airborne bacteria as a cause of wound infections, he gave up the carbolic spray, and throughout the surgical world the air came to be ignored as a medium for transporting the bacteria causing wound contamination. Gradually surgeons came to realize the danger of droplet contamination from the noses and throats of the occupants of the operating rooms, and masks of a totally inadequate type came to be worn, first over the mouth and then also over the nose.

As a result of (1) the great reduction in contact contamination, (2) the increased knowledge of the importance of leaving the wound in the best condition to cope with the reduced number of contaminants, (3) the improvements in anesthesia, (4) the increasing knowledge of shock and its prevention, (5) the introduction of parenteral fluids of all types, particularly blood transfusions, and (6) the increasing knowledge of function and physiology of various parts of the body, the extent and magnitude of surgical procedures were greatly extended.

INCIDENCE OF "UNEXPLAINED INFECTIONS"

Early Experience.—With this increasing scope of surgical procedures, and thus with one or more of the following conditions prevailing (1) exposure of larger denuded areas, (2) for longer periods of time, (3) in operative procedures with greater trauma, (4) with poorer hemostasis, (5) where the wound could not be immobilized, (6) in tissues with poor local resistance, and (7) frequently in de-

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bilitated patients, so called "unexplained infections" became more and more common with all too frequent fatalities. Such infections were likely to be grouped at irregular intervals, and many surgeons can recall times when such infections reached serious proportions. Walker in 1930 reported from a teaching hospital in Boston an infection rate of approximately 20 per cent for December, January and February and 42 per cent for March, dropping off to an average of 8 per cent for the months of April through September. In March the percentage of streptococcal wound infections rose to 10.5 per cent at which time 50 per cent of the operating room personnel were carriers of the hemolytic streptococcus. During the influenza epidemic of 1918 many operating rooms were closed except for emergency cases "because of the widespread dissemination of streptococci." So far as we know, at this time the air was not considered as a medium for transporting these organisms. Masks were widely used, at least over the mouth and emphasis was at times placed on the danger of droplets from talking, coughing and sneezing. It was urged that the masks (fairly adequate to stop large droplets but totally inadequate to prevent air contamination with finer particles) be worn over the nose and mouth.

One of the authors (D.H.), while serving as resident on a busy neurosurgical service in 1924-25, witnessed a series of fatalities from unexplained infections. A widely known bacteriologist was called in to pass on every step of the aseptic technic and after careful observation for several weeks he pronounced that the "technic was airtight" but he entirely ignored the air. With certain changes in the sterilizing technic (a longer period of time at a higher steam pressure) there were no serious infections for a period of a year, and it was thought that inadequate sterilization of supplies had been the cause of the infections. Later the infections again occurred despite the changed autoclaving technic. In retrospect it would appear that these cycles of high and low infection rates were associated with changes in the bacterial flora of the noses and throats of the operating room occupants.

Individual reports occasionally appeared correlating the organisms in an infected wound with those found in the nose and throat of one of the operating room personnel. In such cases it was generally thought that the wound infection was caused by contact or droplet inoculation. General dissemination of bacteria that floated in the air for relatively long periods of time, and for considerable distances, was not considered as a source.

Experience at Duke Hospital.—Following the opening of the Duke Hospital in 1930, occasional "unexplained infections" occurred. In attempting to prevent these, every phase of our aseptic technic was subjected to critical analysis with a general increase in all precautions to guard against the generally accepted sources of contamination.

There was no appreciable reduction in the "unexplained infections," and there was an occasional fatality. These occurred almost entirely in such large operative procedures as thoracoplasties, craniotomies and arthroplasties. Finally with a widespread increase in the nose and throat contamination with *Staphylococcus aureus* (70 to 80 per cent of the general population) and with several heavy carriers among the operating room personnel, six deaths occurred from such infections within a period of three months, forcing us to cease performing operations of election until general conditions improved.

During the years 1930 through 1935 there were seventeen deaths from unexplained infections. Thus within these three months occurred 35 per cent of such deaths for the five and one half year period. The epidemic nature of these infections is even further emphasized by the fact that during these three months there were performed only 15 per cent of the approximately 15,000 operations for the entire period.

Before this epidemic occurred, we had concluded that pathogenic bacteria floating in the air and sedimenting on the wound and sterile supplies caused most of these "unexplained infections." Repeated cultures of every phase of technic including the incoming air convinced us that the pathogenic bacteria in the air of the operating room originated in the noses and throats of the occupants. We reduced the degree of air contamination by ventilating the room with large quantities of air rendered relatively free of bacteria by washing and filtering. Even though the reduction was appreciable, we continued to have occasional infections. Attempts were then made to control this air contamination by limiting the number of occupants of the operating room, elimination of persistent carriers, improvement in and more constant wearing of masks, performing large clean operations only as the first procedure in the morning after the room had been free of occupants overnight, and finally by postponing until the summer months, when the carriers are few, those procedures which were not urgent. The latter of these was the most effective as exemplified by the fact that of these 17 deaths from "unexplained infections" in clean operative wounds, not one occurred in May, June, July or August, while 41 per cent occurred in December and January, 18 per cent in November and February, 29 per cent in October and March, and 12 per cent in September and April. The facts that no deaths occurred during the summer months when the air contamination was repeatedly demonstrated to be low and that the greatest mortality occurred during the winter months when it was known to be high were more than suggestive that the organisms entered the wound by way of the air.

Ultraviolet Radiation of Air—By 1934 we had demonstrated that these airborne bacteria could be killed even at considerable distances (6 to 10 feet) by means of ultraviolet radiation. It was early in 1936, however, after many animal experiments, before we had convinced

ourselves that we could operate in such a field without danger to the wound, and before we had equipped an operating room for use with patients. This addition to the generally accepted aseptic technic has all but eliminated our infections in clean operative wounds and not one of these has been severe.

COMPARISON OF PERCENTAGES OF INFECTIONS IN THORACIC AND GENERAL SURGERY 1936-1941 AND IN THORACIC SURGERY 1942-1946

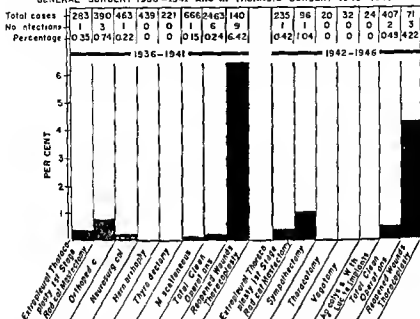


Fig. 446—The slightly higher infection rate (less than 0.5 per cent) for the total clean operations for 1942-1946 as compared with 1936-1941 is explained by the fact that the smaller operations which never become infected have not been included.

The higher infection rate in the reopened wounds for both periods can be explained. The air contaminants have been largely eliminated but the resident skin flora even though of low pathogenicity are still present. They rarely cause an infection in a primary incision but may produce stitch abscesses with a greatly increased number of bacteria about the skin sutures but not showing signs of suppuration. When any wound is reopened at an early date after removal of the skin sutures these bacteria are disseminated through the superficial part of the new incisions and may from their numbers produce a mild or moderate suppuration usually in the subcutaneous fat.

A reported analysis of all operations performed with ultraviolet radiation for the years 1936-41 (Fig. 446) shows an infection rate of only a fraction of 1 per cent ranging from no infections in 439 herniorrhaphies and 221 thyroidectomies to one infection in 463 neuro- and

formed in a field of ultraviolet radiation, now many potentially contaminated operations such as intestinal resections are performed in such a field. This is done in order to avoid introducing the airborne organisms and also to reduce the number gaining access to the wound from the gastrointestinal tract.

We have recently analyzed the operations on the chest performed during the years 1942 through March, 1946, and these are also shown in Figure 446. (In evaluating these statistics, it should be kept in mind that thoracic operations as demonstrated in the period 1936 to 1941 have next to the highest infection rate of any of the groups of cases analyzed.) Following a total of 413 clean primary incisions there were only two infections, giving a rate of less than 0.5 per cent. Breaking

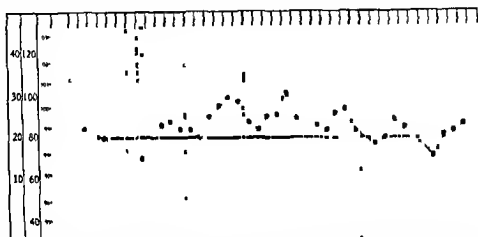


Fig. 447—Temperature curve for one day before and six days after radical mastectomy on the patient described in Case I as showing a mild infection. This did not follow the clinical course of an infection. Bloody fluid was aspirated only once followed by complete healing without reaccumulation of fluid. It is recorded as infected since the culture report on the aspirated fluid was positive for *Alcaligenes faecalis*.

this down we find that there were 81 primary incisions for thoracoplasty with no infection, 163 radical mastectomies with one infection (Case I), 148 thoracotomies, 20 for tumor, 32 for vagotomy, and 96 for sympathectomy with only one infection in the latter group (Case II). Both of these infections were mild as is demonstrated by the following abstracts and temperature curves.

CASE I—A 59 year old white widow entered the hospital with a chief complaint of a lump in her left breast first noticed two weeks previously. On November 4, 1944, a biopsy revealed undifferentiated carcinoma and a radical mastectomy was performed. The temperature curve for the first six days is shown in Figure 447. The fine cotton skin sutures were removed on the sixth and the stay sutures on the tenth postoperative day, on both occasions the wound was described as showing no evidence of separation or infection. On the fourteenth postoperative day, 60 cc. of old blood was aspirated from the superior portion of the

wound Routine culture of this material was reported as showing *Alcaligenes faecalis* There was no further accumulation of fluid, and the patient was discharged on the twentieth postoperative day, remaining in the hospital for this length of time in order to complete a course of x ray therapy The discharge note stated that the wound was well healed The patient received chemotherapy in the form of oral sulfadiazine, 6 gm a day, from the third to the twelfth postoperative day The temperature remained between 37° and 37.5° C (98.6° and 99.5° F) except for two elevations to 37.9° and 38° C (100.2° and 100.4° F) on the eighth and ninth days respectively

On the patient's return to the outpatient clinic one month following discharge the wound was noted as being well healed with no evidence of infection

CASE II—A 34 year old white paperhanger was admitted to the hospital for surgical treatment of hypertensive cardiovascular disease On August 30 1944 a transthoracic paravertebral sympathectomy was performed on the right side The

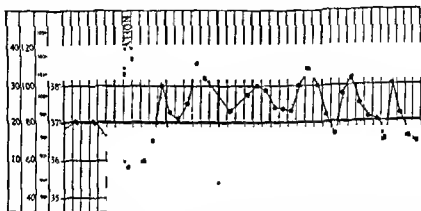


Fig 448—Temperature curve for one day before and six days after a transthoracic sympathectomy for hypertension (Case II) A small collection of fluid drained spontaneously from the superficial part of a catgut closed wound about the eleventh postoperative day and was described by the operator as infected but no culture was obtained Healing was complete by the eighteenth postoperative day, and there was no temperature elevation above 37° C (98.6° F) after the first six days following operation as shown

postoperative course was complicated by the fact that drainage had not been instituted at operation and on the fourth postoperative day, a thoracentesis with the removal of 700 cc of bloody fluid had to be performed At this time he had a temperature elevation to 39.4° C (102.9° F) On September 23 1944 a transthoracic paravertebral sympathectomy was performed on the left side with a Pezzer catheter inserted between the eighth and ninth ribs for drainage of the thoracic cavity The temperature during the first six postoperative days is shown in Figure 448 The drainage catheter was removed on the sixth postoperative day On inspection of the lower wound on the eleventh postoperative day, a "small" abscess was found which had already opened Warm saline compresses were applied and the infection promptly cleared with complete healing of the wound by the time of discharge on the eighteenth postoperative day The patient was given oral sulfadiazine, 6 gm a day from the second to the twelfth and penicillin 30 000 units a day from the fourth to the twelfth postoperative days The temperature

dropped to 37° C (98.6° F) on the sixth postoperative day and remained at or below 37° C for the remainder of his stay. On the patient's return for a check-up three months postoperatively, the incisions were observed as being well healed.

As further evidence of the value of ultraviolet radiation for reducing the bacterial contamination of the air with resultant improvement

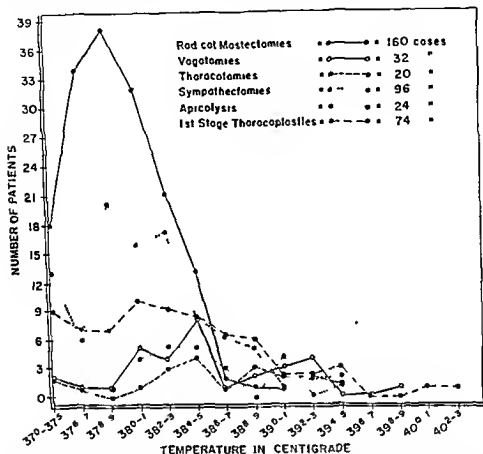


Fig. 449—Maximum temperature elevations for each of the thoracic operations performed for the years 1942 through March, 1948, arranged according to operation as indicated. These were all extensive operative procedures, most showing a relatively slight temperature reaction. Attention is called to the fact that the patients having a thoracotomy that was not drained (vagotomies and thoracotomies for tumors designated as "thoracotomies") and those having an apicolysis with a foreign body implant ran slightly higher average temperatures than the patients having other thoracic operations. For 83 per cent of the entire group the postoperative temperature did not go above 38.5° C (101.3° F).

in wound healing two reports may be cited, one from the state sanatorium in North Carolina, as given in a personal communication, and the other by Overholt and Betts. The former report gave an infection rate of 25 per cent without radiation, whereas in the first 100 thoracoplasty stages after the introduction of radiation there was only one

infection and that in a reopened wound. In the latter report Overholt gave 13.8 per cent infections in clean thoracoplasty wounds without radiation. By improvements in surgical technic leaving the wound in a better condition to cope with the contamination this was reduced to 6.53 per cent. Then by the introduction of ultraviolet radiation to reduce the air contamination this infection rate was reduced to 2.67 per cent. Most of the latter were slight and superficial with only 0.49 per cent clinically significant. From the illustration showing the operating room and the chart giving the reduction in bacterial content of the air it is evident that the intensity of radiation used and the bacterial reduction obtained were less than has prevailed in our operating rooms.

As contrasted to these low infection rates other recent reports in the literature are as follows. Wu and Besso Pianetto in 1943 reported 11.8 per cent infections in 339 stages of thoracoplasty after certain measures had been taken to reduce the dangers from skin and air contamination; no infections occurred in 120 stages.

Cory in 1943 reported 69 per cent of thoracoplasty wounds showed primary healing before the use of sulfathiazole and 93 per cent showing primary healing with the use of sulfathiazole.

Adams and Dufault in 1941 reported 9.9 per cent infections in 241 stages of thoracoplasty.

Dieffenbach and Crecca in 1941 reported 10 per cent infections in 100 thoracoplasties including all stages.

G. G. Finney in 1941 reported that in 104 thoracoplasties all stages there were fourteen slight, eight moderate and three severe infections. Leaving out the slight infections which were probably stitch abscesses he reported an infection rate of 10.6 per cent.

Meltzer in 1941 reported in 181 cases of thoracoplasty all stages three stitch infections, four subcutaneous infections and one severe infection resulting in death. In the latter case a tuberculous cavity was entered during the operation.

POSTOPERATIVE ELEVATION OF TEMPERATURE AND ITS DURATION

As has been reported in a previous publication the virtual elimination of airborne bacteria resulted in a great reduction in the postoperative temperature elevation and the duration of this elevation. The temperature curves on all patients having thoracic operations for the years 1942 through March 1946 were analyzed as a further method of evaluating their reaction to these operations with a very low bacteria count. (Fig. 449) it is seen that for the stage thoracoplasties (74) and the sympathectomies (96) (thoracotomies where drainage of the pleural cavity was instituted to remove

any accumulation of blood), a total of 330 operations, 43 patients (13 per cent) did not have a postoperative temperature elevation above 37.5°C (99.5°F), 213 patients (65 per cent) did not run a temperature elevation above 38.1°C (100.6°F), while 289 patients (88 per cent) had their postoperative temperature remain at or below 38.5°C (101.3°F). Only 41 patients (12 per cent) had a postoperative temperature elevation above 38.5°C (101.3°F).

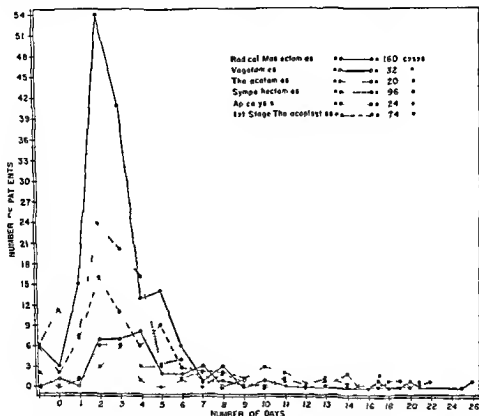


Fig 450—Showing the duration of any temperature elevation above 37.4°C (99.3°F) for each of the thoracic operations shown in Fig 449 for temperature elevation. The patients having a thoracotomy without drainage of the pleural cavity and those with an apicolysis and foreign body implants experienced a temperature elevation for a somewhat longer average time. The temperature of 78 per cent of all the patients was down to 37.4°C or below by the fourth day following operation.

Equally as striking as this predominantly slight temperature elevation in the postoperative course of most patients was the short duration of any elevation above 37.4°C (99.3°F) (Fig 450). In this same group of radical mastectomies, first stage thoracoplasties, and sympathectomies, 18 patients (6 per cent) had no postoperative temperature elevation, while the temperature of 229 patients (70 per cent) was down to 37.4°C (99.3°F) or below by the third day postoperative. Thus only 30 per cent of these patients had any eleva-

too of temperature above 37.4°C (99.3°F) for longer than three days postoperatively (Fig 450)

It is seen from Figure 449 that the temperature elevation was slightly higher, and from Figure 450 that the duration of the temperature elevation was slightly longer for the thoracotomies performed without drainage to remove any accumulation of blood (vagotomies [32] and for removal of tumors [2-]) and for apicolysis (24) with methyl methacrylate plombage where a foreign body was left in the wound. This slightly greater reaction was thought to be due to either the accumulation of blood, or the presence of the foreign body or both.

In contrast with the seventeen deaths from "unexplained infections" during the years 1930 through 1935 (total operations 15,508) there has been no such death during the years 1936 through March 1946 where ultraviolet radiation was used* (approximately 15 per cent of the 69,743 operations performed)

With the low infection rates which we have now maintained for a ten year period in all types of wounds, even during epidemics of respiratory tract contamination the number of bacteria entering our wounds obviously has been relatively low. This has been confirmed by wound irrigations and cultures of the irrigating fluid. With this fact established, it seemed to us that a smooth, nonirritating foreign body could be transplanted into the wound and would become encapsulated with a negligible risk of infection. This work, carried on by Dr. Wilson, the resident hospital surgeon, is summarized in a separate article in this issue. Up to April 1, 1946 we have performed twenty-four apicolyses including those reported by Dr. Wilson, with the implantation of from eighteen to seventy-two spheres of methyl methacrylate per patient, each sphere measuring 2.5 cm in diameter. These were designed for easy insertion and retention within the thoracic cage for the purpose of holding the cavitated lung in a collapsed position with the minimal risk of ulceration into the cavity.

Most of the patients in this series have had far advanced disease and have been considered unfavorable for thoracoplasty. The details of this operation are given in the papers of Dr. Wilson. So far no wound having methyl methacrylate plombage has become infected, no spheres have been extruded or ulcerated into the cavity, and all spheres have apparently become encapsulated.

SUMMARY

In conclusion the virtual elimination of airborne pathogenic bacteria by ultraviolet radiation has accomplished the following results:

1. Eliminated all deaths from "unexplained infections."

* Two such deaths occurred in patients operated on when ultraviolet radiation was not available: radical dissection of the glands of the neck for carcinoma and craniotomy for inoperable brain tumor.

2 Reduced "unexplained wound infections" to a fraction of 1 per cent

3 Diminished greatly the severity of the infections that have occurred

4 Improved wound healing in every case with less local and systemic reaction

5 Made possible the implantation and encapsulation of nonirritating foreign bodies with virtual absence of the dangers of infection and extrusion

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CHEST INJURIES

Application of Military Experience to Civilian Practice

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THE war has stimulated interest in traumatic surgery and has enabled surgeons in the military service to crystallize ideas and formulate policies in the care of the injured that would have taken years to develop in civilian life.

Chest injuries of all kinds have been seen in large numbers in military hospitals of the various echelons of medical care during the war. Our experience in a fixed hospital in England in the center of the Eighth Air Force area where we received fresh battle casualties from crew members of high altitude bombing missions and plane crashes afforded us opportunity to observe a wide variety of these injuries. In addition this hospital acted as a chest center for ground force casualties evacuated from the continent during the latter months of the war in Europe.

TABLE 1—RELATIVE INCIDENCE OF VARIOUS TYPES OF CHEST INJURIES IN
AN ARMY HOSPITAL

	Fresh Injuries		Chest Center Casualties	Evacuated Casualties
	Penetrating	Non penetrating		
Chest wall	32	31		
Pleural cavity (penetrating)	16		74	283
Contusion of lung	6	25		
Hemothorax	6	13	32	45
Pneumothorax		3		
Hemopneumothorax	6	7	20	18
Traumatic asphyxia		2		

Patients covered by this experience (Table 1) include 128 casualties with fresh chest injuries, 74 evacuated chest casualties received by the hospital in its capacity as a chest center, and 283 evacuated casualties.

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with chest injuries, many incidental to other more serious injuries, treated in the chain of evacuation of battle casualties from front line installations. From this experience, and that of others working under similar circumstances, certain conclusions may be made which may be helpful in the management of chest injuries of civilian life.

In discussing chest injuries it is the usual practice to consider such injuries under two separate and distinct headings, penetrating and nonpenetrating wounds, as though the problems of the two were foreign to each other. As a matter of fact, with few exceptions the problems of both types of wounds are similar and it is better to consider them together.

The principal danger of a chest injury arises from a disturbance in the cardiorespiratory mechanism which follows the injury. Blood loss and infection may also be causes for concern, although they are rarely of significance in civilian injuries.

This disturbance in respiratory function may arise from a wide variety of combinations of circumstances. In our experience, excluding injuries to the heart, it most commonly follows any one or combination of the following conditions: contusion of the lung, loss of stability of the chest wall, pneumothorax, or hemothorax. All of these are common to both penetrating and nonpenetrating injuries.

A discussion of each of these conditions plus a brief consideration of the additional problems of the open chest wound (continued blood loss, retained foreign body, open pneumothorax and infection in chest wall or pleural cavity) will include a complete account of the commoner conditions to be encountered in chest injuries of civilian practice. Each will be discussed in the light of military experience.

In the recognition of each of these conditions and their changing nature from hour to hour and day to day, emphasis should first be placed on the importance of frequent bedside x-rays of the chest. Much can be learned from physical examination, and frequent examinations are necessary. However, their interpretation is too uncertain and it is only by combining physical findings with repeated x-rays that accurate information on the changing nature of the conditions present can be maintained.

CONTUSION OF THE LUNG

Contusion of lung tissue with some degree of laceration commonly follows injuries to the chest. It is present in all penetrating wounds of the lung and we found evidence of it in 30 per cent of nonpenetrating injuries from blows, crushing injuries or "bomb blast." It may be present without rib fracture. Edema and hemorrhage are present throughout the involved lung parenchyma. Pleural lacerations with pneumothorax, hemothorax or both may complicate the lesion. In the more severe injuries lung tissue is extensively lacerated and bronchi

are ruptured. At autopsy the lung is dark red and firm in consistency.

If the involved area is not large the only symptom is pain in the chest and bloody expectoration. If the injury is severe or widespread, serious interference with respiratory exchange may develop because of widespread contusion of lung tissue and filling of the alveoli and bronchi with blood and tissue fluids.

The syndrome of the "traumatic wet lung," in which fluids in the tracheobronchial tree are present in such excessive amounts that the patient may literally drown in his own secretions, is present in patients with severe lung contusion. Brewer, Burbank, Sampson and Schiff¹ have indicated that other factors beside lung contusion may enter into the picture. These are excessive reflex secretions of bronchial fluids secondary to trauma, anoxia or tracheal obstruction, and inability to expel fluids from the bronchial tree adequately because of pain or instability of the chest wall from multiple rib fractures or from inhibition of the cough reflex by oversedation or head injury.

Management of this condition is by oxygen administration, relief of pain by intercostal block which often enables the patient to eliminate his secretions himself, and by catheter or bronchoscopic aspiration of blood and secretions in the tracheobronchial tree, if necessary.

It should be emphasized that any patient with chest injury who is having difficulty in eliminating tracheal or bronchial secretions must be given assistance if adequate respiratory exchange is to be maintained and atelectasis of lung segments prevented. It may be that relief of pain by support of the chest or by intercostal nerve blocks will enable the patient to empty the respiratory passages himself by coughing. Or changes in posture with firm but gentle fist percussion over the interscapular region of the back may assist in dislodging tenacious plugs of secretions which may then be expelled by coughing. If these measures are not effective, passage of a catheter into the tracheobronchial tree with suction as described by Haight² is advisable. If this is not possible bronchoscopic aspiration should be prompt.

LOSS OF STABILITY OF THE CHEST WALL

Paradoxical respiration from loss of stability of the chest wall following trauma is not a frequent cause of respiratory distress. When present, however, its recognition is extremely important as it can usually be managed quickly and effectively. If left untreated, particularly if it exists with other types of chest trauma, as is usually the case, serious consequences may develop.

Multiple fractures of several adjacent ribs, or separation of the sternal plate from the thoracic cage because of multiple fractures of the ribs anteriorly on each side of the sternum are the usual cause for loss of stability of the chest wall and the development of para

doxical respiration. In this situation, when the thoracic cage is elevated and expanded as is necessary in inspiration, the detached segment of the chest wall does not elevate but in reality is sucked in. On expiration this segment, instead of falling in, is pushed out (Fig. 451). The detached segment moves in opposite direction to the chest wall. The net result is a serious impairment of respiratory ex-

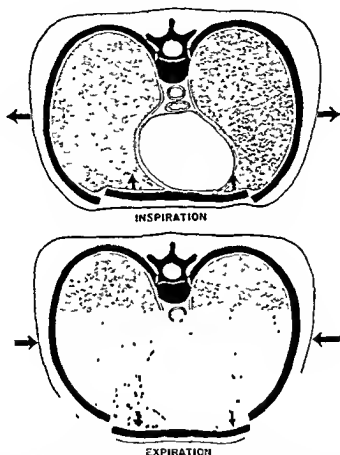


Fig 451—Diagrams to show loss of stability of the chest wall following a crushing wound. The detached sternal plate moves in opposite direction to the chest wall during respiration and produces a paradoxical respiration.

change. The patient is dyspneic, cyanotic and complains of pain at the site of injury.

Some method of stopping this paradoxical motion of the chest wall is urgently needed. If the mobile segment of chest wall is not too large it may be stabilized by strapping with adhesive. If this is not immediately satisfactory, as is usually the case with separation of the sternal plate, wires may have to be placed under the separated rib segments and attached to an overhead pulley with weights which will suspend and immobilize this segment.

Pain is usually relieved by such immobilization, though intercostal nerve block may be necessary. Oxygen is administered until respiratory exchange is normal. As in all chest wounds, frequent x-rays are necessary to detect the presence of an attendant pneumothorax, hemothorax or lung contusion which may also need treatment.

PNEUMOTHORAX

Air may escape into the pleural cavity from a tear in the lung or a hole in the chest wall. The lung may be ruptured from a crushing injury with or without rib fracture, or it may be lacerated by the sharp ends of indriven rib following a direct blow (Fig 452). Ordinarily, unless a tension pneumothorax develops or other chest injuries are severe, the presence of air in the pleural cavity is not a serious

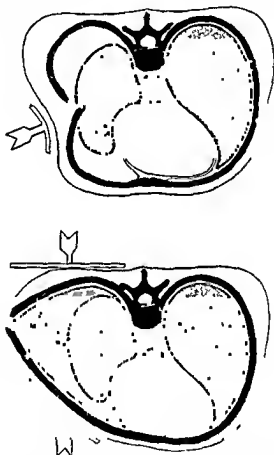


Fig 452—Diagrams showing two methods by which pleuropulmonary injury may follow nonpenetrating injury of the chest by direct blow or crushing injury

injury with or without rib fracture, or it may be lacerated by the sharp ends of indriven rib following a direct blow (Fig 452). Ordinarily, unless a tension pneumothorax develops or other chest injuries are severe, the presence of air in the pleural cavity is not a serious

complication. If it is causing respiratory embarrassment, the air may be withdrawn. Otherwise, it ordinarily is rapidly absorbed.

Tension Pneumothorax.—Sometimes a valvelike action at the pleural tear in the lung allows air to enter the pleural cavity with each inspiration but not to escape during expiration. Air gradually builds up in the pleural cavity under positive pressure. The lung on the affected side becomes collapsed, the mediastinum becomes displaced to the unaffected side and serious interference with respiratory exchange develops.

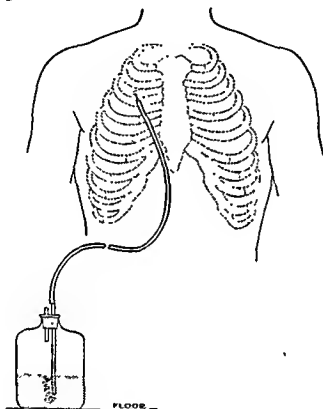


Fig. 453.—Sketch of the method used in releasing air from a tension pneumothorax

Air must be withdrawn from the pleural cavity promptly if the patient is to escape death from suffocation. This can be easily accomplished by inserting a needle through the second or third interspace anteriorly and connecting the needle to a finger cot or condom which has a slit in its end, or to a tube whose end is placed under the surface of a flask of sterile fluid on the floor at the bedside (Fig. 453). If the escape of air has not stopped in forty-eight hours, open thoracotomy may be advisable either to remove indriven rib fragments which may be keeping the pleural leak open or to resect an area of damaged lung tissue or suture lacerated bronchi. Open operation is rarely necessary, however.

Subcutaneous emphysema is commonly present when ribs are fractured. If it is increasing rapidly, the presence of a tension pneumothorax must be suspected and a needle inserted into the pleural cavity with underwater seal, before generalized subcutaneous emphysema develops.

HEMOTHORAX

Bleeding into the pleural cavity in patients who survive long enough to reach a hospital usually occurs either from the lung or from intercostal or internal mammary vessels of the chest wall. The dangers of its presence include acute blood loss, interference with respiratory exchange, and loss of lung function with possible infection if a massive clotted hemothorax or a fibrothorax develops.

Bleeding from the lung stops spontaneously as the lung collapses while bleeding from the chest wall may have to be controlled at operation. If the patient is received in shock and the blood pressure once restored by transfusion drops again the possibility of continued bleeding from an intercostal or internal mammary artery must be considered. If blood in the pleural cavity reaccumulates rapidly after repeated aspiration the suspected area must be explored, bleeding vessels ligated and blood and blood clot evacuated. It is surprising however, how rarely this complication develops.

The treatment of hemothorax unattended by continued bleeding has been a subject of controversy in the past. Some have advised leaving the blood alone if it causes no respiratory embarrassment.^{1, 2} Others have recommended withdrawing the blood, but only after three or four days and then replacing it with air in the belief that reexpansion of the lung would cause bleeding from the lung to begin again.³

As a matter of fact, we have never seen bleeding from a lung recur after early aspiration of a hemothorax, while we have repeatedly been impressed by the harmful effect of allowing blood to remain within the pleural cavity.

Contrary to popular belief, blood which escapes into the pleural cavity clots promptly in most cases. As it clots, the churning motions of heart and lung defibrinate the clot so that fibrin is deposited on parietal and visceral pleuras and liquid defibrinated blood remains in the pleural cavity.^{4, 5} In most instances of small or uncomplicated hemothorax this defibrinated blood and the fibrin are absorbed without deleterious effect. However, it has been demonstrated that this liquid defibrinated blood acts as an irritant within the pleural cavity. The inflammatory exudate which it stimulates contains more fibrinogen which causes secondary clotting to occur with deposition of additional layers of fibrin over pleural surfaces. Sellors⁷ has shown that the fibrinogen content of untapped hemothoraces rises from an initial

level of zero to a level higher than that in the blood after a week or so. Increase in pleural reaction with thickening from layered deposits of fibrin thus may result when blood is left within the pleural cavity.

This harmful effect of leaving blood in the pleural cavity is probably of greater importance in war wounds where other causes of inflammation are present within the pleural cavity (foreign bodies, traumatized tissue, low grade infection), in addition to blood. However, this effect emphasized the advisability of early and repeated aspirations of blood in the hemothorax of civilian injuries as well as military ones. If air is introduced the only result is an apical collapse and a more prolonged period of time before expansion of the lung can be obtained.

As a result of these facts it is now generally agreed among military surgeons^{8 9 10 11 12 13 14} that a hemothorax is best managed by early and repeated aspirations in an effort to keep the pleural cavity dry and the lung fully expanded at all times. It has been our policy to withdraw all the blood that can be obtained beginning twenty four hours after the injury (earlier if it causes respiratory embarrassment). The volume of blood removed is determined by the patient's reaction. A complaint of tightness in the chest is taken as an indication to stop the aspiration. From 500 to 1000 cc can usually be removed at each thoracentesis. Aspirations are continued daily or every second day until the chest is dry and remains so.

Clotted Hemothorax or Chronic Fibrothorax—In most cases blood in the pleural cavity, though it clots at first, quickly becomes liquid as it becomes defibrinated by the action of the lung and heart. In a small proportion of cases, about 5 per cent, either massive clotting of the blood occurs immediately, or a large accumulation of fibrin develops later which prevents its removal by aspiration. In the first instance, clotting of the hemothorax occurs immediately probably because of the sudden development of a massive hemothorax which completely collapses the lung and thus eliminates the defibrinating action of its motion (Fig 454, A). In others, usually as a result of delayed aspiration, a time is reached about four or five weeks after injury when massive accumulations of fibrin and isolated pockets of serum develop within the pleural cavity which cannot be aspirated (Fig 455, A). In this latter event, the fibrinogen introduced into the pleural cavity with the inflammatory exudate caused by the trauma and retained liquid blood causes a secondary clotting and deposition of additional fibrin over pleural surfaces. In either event the lung is crippled and held collapsed and the chest wall and diaphragm are immobilized by the dense fibrous scar which forms over parietal and visceral pleural surfaces.

In the case of a massive clotted hemothorax (Fig 454, A) the thorax on the affected side is ballooned out at first and moves freely

with respiration. In the case of the chronic fibrothorax, which develops after four or five weeks the affected side of the thorax is smaller and moves little or not at all on respiration. Intercostal spaces are nar-



Fig 451—A Massive clotted hemothorax in an infantry soldier which developed on the night of thoracotomy for perforating wound in a field hospital on the continent three weeks previously. B Same patient on day of evacuation of the clot and decortication showing the three drainage tubes in place. C Same patient three weeks after operation.

rowed and the trachea is sometimes deviated to the affected side (Fig 455 A).

In the past these conditions have been poorly understood and usually badly managed because no one surgeon saw enough of them to formulate a policy for their management. One of the real contribu-

tions of military medicine^{15, 16} has been the development of the concept that if infection in lung and pleural cavity is to be prevented and if the imprisoned and collapsed lung is to be reexpanded, this

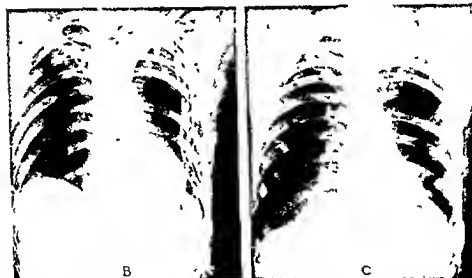


Fig. 455—A, Chronic fibrothorax thirty-five days after multiple shell fragment wounds with unrecognized and untreated hemothorax. The apex of the lung is collapsed, the interspaces are narrowed, the diaphragm elevated and trachea and mediastinum are displaced toward the affected side. B, Same patient on day of decortication showing the three drainage tubes in place. C, Same patient twenty five days after operation.

thickened scar which envelops the lung and coats the chest wall and diaphragm must be removed. The procedure is called *decortication*. It includes the removal of all clot, the careful dissection of the thickened pleural scar off the entire lung and the removal of the scar from

mediastinum, chest wall and diaphragm. The same procedure is used in cases of infected, clotted hemothorax or fibrothorax.¹⁷

The clot and fibrin usually occupy a posterolateral position in the pleural cavity and extend from diaphragm to apex, being widest at the base of the thoracic cavity. In order to obtain adequate exposure for their removal, a long segment of the sixth rib is resected through a posterolateral incision. On entering the pleural cavity, clotted blood and fibrin are removed manually. A line of cleavage is developed between visceral pleura and the fibrous scar which encases the lung. This scar tissue is usually 1 to 3 mm in thickness. It is stripped off the lung by a combination of sharp and blunt dissection using care not to tear into the lung. The dissection frees the lobes and also portions of the lung margins which are often folded back upon themselves or telescoped into collapsed segments. The entire lung is freed. When this is done the anesthetist inflates the lung and the full and complete expansion of each lobe is demonstrated. The scar covering diaphragm and parietal pleura is usually at least twice as thick as that covering the lung. It can usually be peeled off the chest wall with the finger without difficulty. Its removal is important if full motion of the chest wall is to be attained. At the close of the operation the pleural cavity is irrigated with saline solution and 100,000 units of penicillin left in the pleural cavity.

It has been our uniform practice to drain the pleural cavity for forty-eight hours after operation. Since one of the main purposes of the operation is to attain full expansion of the lung and since this may be defeated by collections of blood or serum or by air which may leak from tears in the lung which are almost inevitable in the dissection of the pleural scar, we feel this drainage is imperative (Figs 454, 455). We usually use three large tubes with multiple openings, extending from apex to base and emerging just above the diaphragm. One is placed anteriorly, one laterally and one posteriorly. Each is attached to an underwater seal. If air escapes and negative pressure is not attained in each of these tubes an artificial source of negative pressure is attached to these tubes until the pleural leak is sealed. This has always occurred by the third day, in our experience.

The patient is permitted to leave his bed on the second postoperative day. Chest exercises to obtain full motion of the affected side of the thorax are begun immediately and rigorously continued throughout the remainder of the hospital stay.

PENETRATING WOUNDS

Penetrating wounds add to the conditions already discussed, the possibility of infection, retained foreign body, or open pneumothorax with possibly a sucking wound and mediastinal flutter.

Most of the penetrating wounds in civilian life (ice picks, "switch" knives, small caliber missiles) will not require operative treatment. The mechanics of how a sucking wound produces asphyxia is well known and the need to close it promptly is taught in all first aid classes. Fortunately this condition is rarely seen in civilian practice. If the wound is large or sucking or if ribs are splintered, débridement of the chest wall with closure of the pleural cavity is necessary. Military experience has shown that irregular shell fragments larger than 1 cm in diameter and indriven rib fragments should be removed, as their retention often leads to infection or hemorrhage. This can usually be done through the wound of entrance, unless the entrance is through the apex, in which case a thoracotomy at the site of election is indicated. In civilian practice smooth, small caliber bullets of more than a centimeter in length can probably be left alone with safety unless they occupy a position close to a major vessel or bronchus.

SUMMARY AND CONCLUSIONS

Penetrating chest injuries in civilian practice rarely require operative treatment. The principal problems of nonmilitary thoracic injuries include trauma of the lung, loss of stability of the chest wall, tension pneumothorax, hemothorax, or a combination of any or all of these factors.

In the appraisal of the nature of these injuries and their progress from hour to hour or day to day, frequent bedside x rays of the chest are necessary.

The significance of lung trauma, "traumatic wet lung," as a cause of respiratory embarrassment has been emphasized and its management clarified by military experience.

Catheter or bronchoscopic aspiration of blood and secretions from the tracheobronchial tree is a valuable therapeutic adjunct in all types of chest trauma if the patient has difficulty in eliminating these secretions himself.

In the management of hemothorax, military experience has emphasized the need for early and repeated aspirations of blood to keep the pleural cavity dry and the lung fully expanded at all times.

Clotted hemothorax and chronic fibrothorax have been poorly understood and badly managed in the past. Military experience has standardized an operative procedure and demonstrated its value in those cases in which the lung is held collapsed and chest wall and diaphragm are immobilized by dense layers of scar tissue which have been laid down as a response to blood retained in the pleural cavity for long periods of time.

PLASTIC SURGERY OF THE BREAST

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AND JAMES B. HOLLOWAY, Jr, M D †

THE breast in disease is an object of the general surgeon's most serious concern. In contrast, the correction of various abnormalities and deformities of the breast, in the absence of neoplastic processes, is a more specialized field lying within the province of the plastic surgeon, who may relieve the patient of physical disability, discomfort and mental embarrassment. To allow a woman to make the best of hypertrophied breasts, that weigh as much as fifty pounds (Fig 456), or lesser abnormalities which may alter her posture, impair her



Fig 456—Massive gravid hypertrophy of the breasts in a Negress. Any movement was extremely laborious and awkward. Pain was intense and constant. An overhead traction apparatus was designed to relieve respiratory embarrassment. The right breast weighed 35 pounds (15.9 kg), the left weighed 25 pounds (11.4 kg).

attractiveness, limit her economic or social opportunity, or destroy her happiness, is not justifiable. The medical profession in general has not given full attention to the prevalence and attendant discomforts of the various non neoplastic conditions of the breast, and many physicians are unaware of the safe and successful methods of repair which are available. This may be due, at least in part, to the appear-

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ance in the American literature until the past decade of few articles on plastic surgery of the breast. With the evolution of the various surgical procedures for mastopexy reviewed by Thorek¹ and the advances in various techniques and principles the operation has developed from simple removal of excess skin to complete reconstruction of the breast.

COMPARISON OF SURGICAL PROCEDURES FOR THE CORRECTION OF THE PENDULOUS BREAST

The two main *procedures of choice* for the correction of the pendulous hypertrophied breast among the numerous techniques applied from time to time are generally considered to be (1) the transposition of the nipple and areola to an elevated position while still attached to the underlying breast and (2) free transplantation of the detached nipple. In some instances however it may be impractical either to transpose or transplant the nipple and as in the instance of the case to be described there is no alternative other than the construction of an artificial nipple—a *procedure of necessity*. Regardless of the method of repair utilized for the correction of the pendulous hypertrophic breast the procedure should embrace the principles emphasized by Maliniak² (1) preservation of the blood supply of the breast to prevent necrosis of any part (2) avoidance of extensive injury to the ducts to preserve mammary function, if it is present, (3) firm fixation of the reconstructed breast in its new location to prevent recurrence of pendulousness (4) minimization of scarring and (5) reduction of all diameters of the breast proportionately to insure an esthetic end result. Since no single surgical procedure can be applied in all cases these principles must be borne in mind in evaluating the procedures to be described.

Transposition of the Nipple Through a Buttonhole Incision—Transposition of the nipple and areola while attached to the underlying breast to a higher position through a buttonhole incision was originally described by Morestin³ and subsequently adopted with modifications by Dartigue⁴ Passot⁵ Maliniak² and Lamont⁶. A large flap is made on the anterior aspect of the breast and all of the skin is removed from the posterior surface permitting reduction and modeling of the breast in all directions. The nipple and areola are inserted into a buttonhole incision in the anterior flap and the gland, around which a circular incision has been made is firmly sutured to the pectoral fascia to prevent recurrence of ptosis. Scarring is minimized by suturing the flap into the submammary fold. When the operation is performed in one stage there is great danger of necrosis. To avoid this serious complication the authors believe that the two stage operation of Maliniak or that of Lamont⁶ is the *procedure of choice* since either may be used in the great majority of patients. Both

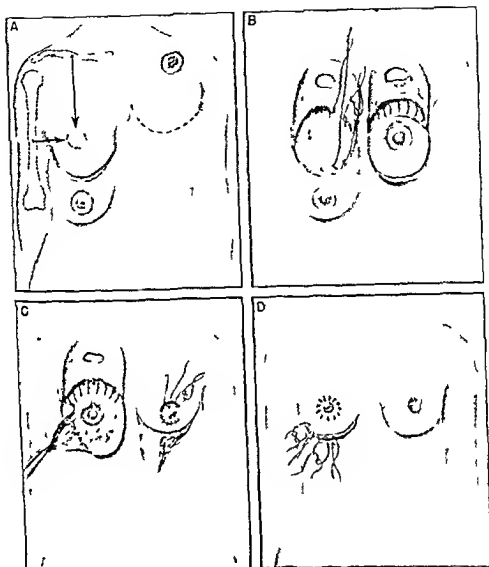


FIG. 1. A. B. C. D.

the areola. A concave incision on the anterior surface of the breast extends from the lateral side of the submammary fold almost to the xiphoid process. B, A heavy skin flap is separated as far as the second rib. The breast is mobilized, and its upper portions are fixed to the pectoral fascia. The anterior flap is then brought down over the elevated breast, and if the predetermined position of the new nipple site is correct, a buttonhole is made here and into it the transported areola is sutured. C, The incision on the posterior aspect of the breast is made several centimeters above the submammary fold (A), the chief consideration being the avoidance of tension on the lines of suture. The second stage of the operation is performed several weeks later. The excess skin, fat and glandular tissue are removed through a crescent-shaped incision in the submammary fold (C, D).

methods allow for breast reconstruction with the desired symmetry, size, and shape.

The *Mahmakiak* operation, involving two stages of reconstruction, is based chiefly on the principle of the preservation of the blood supply in the prevention of necrosis. Mahmakiak abandoned the single stage procedure because his patients developed areas of slough in the flaps due to circulatory insufficiency. Torsion of the pedicle is a factor in reducing the blood supply and can be avoided by taking suitable precautions against rotating the pedicle as the nipple and gland are transposed.

The first stage of the repair is limited to transposition of the partially diminished breast (Fig. 457). A suitable position for the transposed nipple is determined by the intersection of the horizontal line drawn halfway between the clavicle and the elbow and the vertical line through the middle of the clavicle (Fig. 457, A). This point, determined with the patient in an erect position, is marked with a suitable dye, such as a 5 per cent alcoholic solution of brilliant green. The center of the transposed nipple should never be higher than this point. At operation a sandbag is placed between the shoulders and after aseptic preparation of the field, a circular incision is made around the areola, reducing it to approximately 4 cm in diameter. A concave incision on the anterior surface of the breast extends from the lateral side of the submammary fold almost to the xiphoid process (Fig. 457, A). A heavy skin and subcutaneous flap is separated superiorly extending as high as the second intercostal space. The breast is mobilized, and its upper portions are fixed to the pectoral fascia with heavy silk (Fig. 457, B). A buttonhole is made, about 1 cm smaller in size than the originally circumscribed areola, at or below the predetermined point, and into it the areola is sutured. The position of the incision on the posterior surface of the breast is determined in each case by the size of the transposed organ, the chief consideration being the avoidance of tension on the lines of suture (Fig. 457, A). As a rule, this incision is placed several centimeters above the submammary fold. Any reduction of the gland at the first operation is limited to the lower pole. The main branches of the lateral thoracic and the internal mammary arteries are not disturbed. The external angle of the incision is drained.

The second stage is carried out from four to six weeks later, when the nipple has "taken" in its new location. The excess skin, fat and glandular tissue are removed through a crescent shaped incision in the submammary fold (Fig. 457, C, D). Mahmakiak² states that when the correction is bilateral, this procedure does not lengthen the surgical period. In the one stage operation, the corrections are usually performed separately on each breast, thus requiring two surgical procedures for completion. If one performs the first stage of the

operation on each breast at the same time, the repair on both breasts is finished together, and the total time required is the same as with the one stage method (Fig 458)

The *Lamont mastopexy*, though differing in the details of technic from the operation of Malinick, is likewise designed to allow maintenance of the circulation. The proposed lines of incision, which are similar to those described, are marked out the day before operation



Fig 458—Virginal hypertrophy. The enlarged breasts caused pain, physical disability, and embarrassment. The two stage Malinick operation was used to reconstruct the breasts. All diameters of the breasts were proportionately reduced to obtain the esthetic result. The scars are located in the inframammary folds. The nipples have normal erectile power.

The patient is placed on the table in semi Fowler position with the arms akimbo. A circular incision is made around the areola and from it another is made perpendicularly upward to the new nipple site (Fig 459 A). The skin of the breast is undermined in a thick flap. The breast, denuded of skin and with its nipple and areola attached, is pushed up to the desired position on the chest. This allows the operator an opportunity to evaluate the amount and area of breast tissue to be removed. Either two or three triangular wedges of tissue

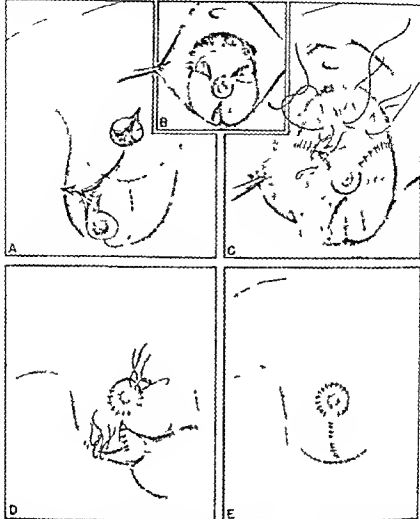


Fig 459—The Lamont mastopexy **A** suitable position for the transposed nipple and the proposed lines of incision are marked out the day prior to operation **A** A circular incision is made around the areola and from it another is made perpendicularly upward to the new nipple site The posterior incision begins at the inferior margin of the areola and extends downward to just above the inframammary fold, where it extends in either direction in the form of an inverted T The skin of the breast is undermined in a thick flap Depending on the amount of breast tissue to be removed two or three triangular wedges of tissue extending down to the pectoral fascia are resected (**B**) The breast now reduced in size is elevated to the desired position and fixed to the pectoral fascia using heavy silk sutures (**C**) A circular or oval button of skin previously marked is removed to serve as the new location of the nipple and into it the areola is sutured (**C**) The skin flaps are so cut as to adjust themselves to the new size contour and position of the breast (**D**) In instances of very large breasts or where revision is necessary the second stage of the reconstruction is performed several weeks later by reopening or excising the inframammary incision and making an incision from its center upward to form an inverted T (**D**) Depending upon the amount of breast to be removed additional wedges or a crescent are resected The flaps are trimmed and sutured without tension (**E**)

extending down to the pectoral fascia are resected. These wounds are closed with interrupted sutures of silk (Fig. 459, B). Three heavy silk sutures are inserted through the pectoral fascia over the second rib and carried through the upper poles of the breast, fixing the breast in its new position (Fig. 459, C).

A circular button of skin, previously marked, is removed to serve as the new location of the nipple which is sutured at the periphery (Fig. 459, D). The skin flaps on either side are brought around the breast,

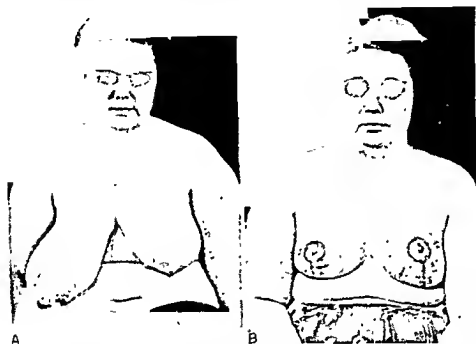


Fig. 460.—A, Asymmetrical pendulous adipose breasts. The Lamont operation was used to reconstruct both breasts. The first dressing was performed on the fifth postoperative day at which time the drains and every other black silk suture were removed. B, Appearance of the patient on the tenth postoperative day prior to removing the remaining sutures. The horizontal lines of the inverted T incision are concealed in the submammary fold.

meeting in the center where the excess is excised. Interrupted sutures of silk are used for the closure. A drain is inserted beneath the flaps.

In instances of very large breasts or where revision is necessary, Lamont performs the second stage of the reconstruction several weeks later by reopening the inframammary incision and making an incision from its center upward to the outer edge of the nipple to form an inverted T (Fig. 459, E). Heavy skin and subcutaneous tissue flaps are reflected, and, depending upon the amount of breast to be removed, additional wedges or a crescent are resected from the inframammary region. The flaps are trimmed and resutured without tension (Fig. 460).

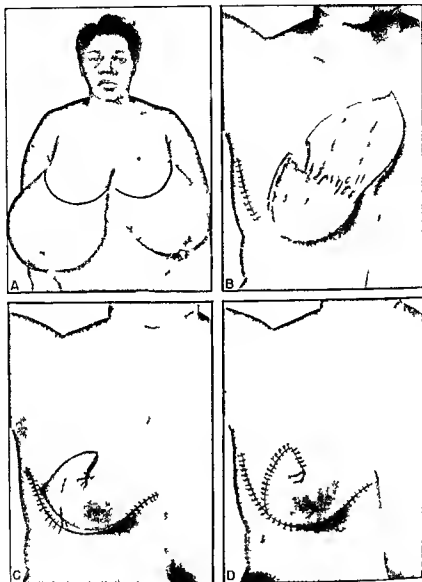


Fig 461—Right mammoplasty subtotal amputation of the breast with construction of an artificial nipple A A crescent shaped incision was made anteriorly over the right breast from the axilla to the xiphoid process A heavy skin flap was mobilized superiorly as far as the clavicle With the breast lifted upward a second crescent shaped incision was made several centimeters above the submammary fold Subtotal amputation of the breast was performed removing all of the tissue between the two incisions The small amount of breast which remained was advanced upward and fixed to the pectoral fascia over the second and third ribs using braided silk sutures Because of the leather like texture of the nipple it was not advisable to use it as a free graft To create the illusion of the presence of a

Free Transplant of the Nipple; Construction of an Artificial Nipple.—This operation, first described by Thorek,¹ has been used also by Updegraff⁷ and Adams⁸ in cases of marked hypertrophy. The writers have avoided use of this procedure through fear of necrosis due to the unsuitable character of the transplant advocated⁸ which, to provide a suitable effect, should involve the nipple, areola and muscular tissue. For this reason, the authors do not regard the procedure as one of choice but as one of necessity. In some instances, satisfactory results in the treatment of massive hypertrophy of the breasts can be attained only by subtotal excision of the enlarged organ and construction of an artificial nipple. An illustration of this is given in the following case report.

CASE REPORT—Subtotal Removal of Breasts Weighing 54 Pounds (24.5 Kg.)—A 22 year old married Negro woman was admitted to the Obstetrical Service of the Duke Hospital March 6, 1945, at which time she was eight and one half months pregnant. She had experienced five previous pregnancies, each of which terminated in a normal full term delivery. The first child was born January 2, 1936. The first four infants were breast fed for periods ranging from three to twelve months. The last child was born May 6, 1943 and after several weeks was placed on a bottle because of "convenience."

The present pregnancy began in July, 1945, at which time the patient's breasts were about the size of a grapefruit or a small head of cabbage. Although there was some increase in size associated with the progression of the pregnancy, the breasts did not begin to increase rapidly in size until she had reached the seventh month. Within three to four weeks they then reached tremendous proportions sufficient to incapacitate the patient almost completely and to necessitate hospitalization. An overhead suspension apparatus was designed to relieve the patient of the great weight. Pregnancy terminated in a normal delivery on March 22, 1945. Attempts to aspirate the breasts on several occasions during the following week yielded only 12 to 15 cc. of milk. The patient was fitted with a home made breast support and allowed to leave the hospital March 29, 1945. Detailed contraceptive instructions were given.

An endocrine survey during the patient's hospitalization disclosed no abnormalities. It was the opinion of most observers that the breasts would regress in size during the postpartum period but that, if this did not occur, plastic reconstruction of the breasts should be performed within six months. The patient did not return until December 12, 1945, when she again was about five months pregnant. Her breasts were now even larger than on her previous admission (Fig

nipple and to obtain the desired contour in reconstruction, a vertical incision was made in the anterior skin flap up to the approximate position of the constructed nipple (B). The incision in the submammary fold was then closed, using interrupted sutures of silk placed obliquely so that the lateral flap was drawn medially and the medial flap laterally when the sutures were tied (C). The vertical limb was closed next. A "dog ear" to simulate a nipple and areola was then formed by making a small incision obliquely downward (D). Since this skin is loose, the pigmentation is deeper and the illusion is quite effective. The specimen weighed 32 pounds (14.5 kg). The incision healed per primam.

Three weeks later a similar procedure was performed on the left breast. The specimen weighed 22 pounds (10 kg).

456) Inasmuch as the breasts were already of great size and movement was laborious and awkward operation was decided upon despite the realization that miscarriage would follow.

Operation Mammoplasty, right breast. Weight of specimen 32 pounds (14.5 kg).—On December 17, 1945, with the patient anesthetized with cyclopropane and ether, a subtotal excision of the right breast was performed and followed by plastic reconstruction of the part that remained. Ice tongs were used to lift the breasts at operation.

A low crescent shaped incision was made anteriorly over the right breast from the anterior axillary fold to the xiphoid process (Fig. 461 A). The vessels in the subcutaneous tissues were markedly enlarged. The anterior skin flap was then dissected superiorly as far as the clavicle. With the breast lifted upward and forward a second crescent shaped incision was made about 3 cm. above the submammary fold. A subtotal excision of the breast was performed as rapidly as pos-



Fig. 462—Postoperative photographs (a) total amputation and reconstruction of the right breast. (b) following the same operation on the left breast. The nipple and areola on the left side are high as compared with the location on the right. This was due to an error in judgment which could easily be corrected. The patient, however, is so pleased with the result that she does not desire any further operations.

On section there were many large lobules of hyperplastic tissue, many of which measured 8 cm. in diameter. The adipose tissue was scanty and occupied only the spaces between the hyperplastic lobules. Large quantities of clear straw-colored fluid escaped as the breast tissue was sectioned. The specimen weighed 32 pounds (14.5 kg.).

Because of the thick leather-like texture of the nipple, it was not advisable to transpose or use it as a free graft. To create the illusion of the presence of a nipple and to obtain the desired contour in the reconstruction, the following steps were carried out. That small amount of breast which remained attached to the chest wall was advanced upward and anchored to the pectoral fascia over the second and third ribs with several braided silk sutures. The remaining gland was

461, B), the flaps were brought toward each other, overlapped, and the redundant parts removed. The horizontal incision just above the mammary fold was closed first, using interrupted sutures of silk placed obliquely so that the lateral flap was drawn medially and the medial flap laterally when the sutures were tied (Fig 461, C). The vertical limb of the incision was closed next with the same suture materials. A "dog ear" to simulate a nipple and areola was then formed by making a small incision obliquely downward (Fig 461, D). Since this skin was loose, the pigmentation was deeper and the illusion quite effective.

Histologic sections showed an "extreme degree of adenomatous hyperplasia." The incisions healed per primam, and the patient was discharged on the sixteenth postoperative day. The fetal heart could not be heard at this time, although the patient thought she experienced fetal movements.

Operation. Mammoplasty, left breast. Weight of specimen 22 pounds (10 Kg).—The patient returned in about three weeks for the operation on the left breast, and on January 24, 1946, a mammoplasty using cyclopropane as the anesthetic agent was performed. The specimen weighed 22 pounds (10 Kg). The same type of operation was performed as upon the previous occasion. Two days later, a macerated fetus was extruded. The operative incisions healed per primam and the patient was discharged on the seventeenth postoperative day, February 10, 1946. Photographs taken several days before discharge (Fig 462) show the left artificial nipple and areola high as compared with the location on the opposite side. This was due to an error in judgment, and although the patient writes that it has descended to a more normal position, she is so pleased with the present result that she does not desire any further operative procedures.

VIRGINAL AND GRAVID HYPERTROPHY

While the majority of cases of virginal hypertrophy (Fig 458) have their onset during adolescence, a similar condition may also occur during pregnancy (Fig 456). Virginal hypertrophy must be distinguished from adipose breasts (Fig 460). Enlargement of the breasts due to deposition of fat may occur in cases of pituitary disturbance, where there is an increase of fat about the hips and in the mammary glands, but the excessive growth seen in virginal hypertrophy does not occur.

"Because the end-organ rather than the hormonal functions is at fault in virginal and gravid hypertrophy, endocrine therapy is unsuccessful." Surgery, therefore, is the only other alternative.

COMMENT

Benign and malignant breast tumors have at least one feature in common: they are formed by abnormal and purposeless multiplication of cells previously derived from normal cells. Benign tumors resemble closely the tissue from which they originate. The cells are arranged in a relatively orderly fashion, and although the tumor may attain great size, it rarely jeopardizes the life of the host except by interference with vital functions by pressure. In contrast, however, malignant neoplasms consist of abnormal cells which may tend to approach the undifferentiated embryonic type. They are not orderly in growth but

invade and destroy adjacent tissues or metastasize to different parts of the body, and finally lead to the death of the patient

Massive hypertrophied breasts are in most instances comparable to benign tumors and should be considered and treated as such. The increased size may be due to enormous deposits of fat, or to marked proliferation hyperplasia and hypertrophy of the breast tissue proper (Figs 456-458-460). Massive breasts not only incapacitate the bearer but are conspicuous and unsightly. The breasts cause self-consciousness in the bearer, are a source of pain and discomfort, and may cause scoliosis, kyphosis or lordosis. The excessive perspiration is unpleasant, and the patients avoid society, become depressed and morose, and an ensuing psychosis may develop.

The indication for surgical removal or correction of hypertrophied breasts is just as real and as fully justifiable, especially in young women, as the indication for many ordinary or well recognized surgical procedures, such as the correction of gynecomastia in the male, or the reduction in size of an elephantoid extremity due to lymphatic obstruction. Thorek¹ has stated that "the average woman regards grace and beauty of form as one of the essentials of life. The fact that thousands of young and middle aged women adopt reducing diets in order to preserve or restore slimness of figure is proof in point." Rather than simply to amputate such breasts, it is much better to remove them in a manner that leaves a pleasing instead of an ugly appearance at their site, if this can be accomplished without increase in the risk. Surgical correction of enlarged breasts is indicated when the hypertrophy leads to a disfiguring or disabling deformity and when there is a reasonable probability that the operation will restore the affected parts approximately to normal without undue danger to the patient. The operation is designed to restore physical as well as psychological balance, and, properly executed, it will accomplish these objectives.

CONCLUSIONS

Markedly hypertrophied breasts are, in many instances, comparable to benign tumors. Plastic surgical correction is indicated when the hypertrophy leads to a disfiguring or a disabling deformity. Three methods of reconstructing pendulous hypertrophic breasts are presented.

The suppression of mammary function is not a contraindication for reconstruction, as normal function is rarely present in the pendulous hypertrophic breast.

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COMPLICATIONS OF THORACOTOMY OBSERVED DURING OPERATIONS UPON THE SYMPATHETIC AND VAGUS NERVES

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THORACOTOMY was considered a hazardous procedure during the early years of development of modern surgery. It was usually employed only for treatment of empyema or of penetrating wounds of the thorax. Increasing knowledge concerning the physiology of respiration and circulation and concerning aseptic surgical technique, anesthesia and chemotherapy has gradually decreased the risk of thoracotomy. Structures within the chest are being approached with increasing safety.

There are several examples of the development of the use of the thoracotomy. Difficulties encountered during early operations on thoracic portions of the esophagus were studied by Sauerbruch¹ in 1905. They were gradually overcome and Torek² in 1913 reported the first resection of the thoracic esophagus. Graham and Singer³ reported the first successful pneumonectomy in 1933. Surgery directed toward the formation of extra coronary blood supply for the heart was begun in 1935 by Beck.⁴ Rienhoff⁵ in 1938 reported resection of the pulmonary plexus for asthma. The larger arteries in the thorax have been successfully approached for aneurysm by Alexander and Byron,⁶ for malformations of the heart particularly pulmonary stenosis, by Blalock,⁷ and for coarctation of the aorta by Gross.⁸

These and other operations demonstrate the prevalent opinion that a transthoracic approach to the thoracic viscera is relatively safe.

The operations described above are associated with a possibility of direct contamination from the esophagus or the lung, or of complications related to major changes of respiration and circulation. The complications or the risk that might be associated with thoracotomy itself are therefore not easily determined.

Transthoracic sympathectomy for hypertension (Grimson⁹) and transthoracic vagotomy for peptic ulcer (Dragstedt¹⁰) are two operative procedures in which the chance of complications related directly to thoracotomy might better be evaluated since unrelated complications are less likely. This report deals with the use of these two operative procedures and particularly with a study of complications observed that seem to be related directly to thoracotomy.

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TOTAL THORACIC AND PARTIAL TO TOTAL LUMBAR SYMPATHECTOMY AND CELIAC GANGLIONECTOMY IN THE TREATMENT OF HYPERTENSION

Complete removal of the two paravertebral sympathetic chains and the splanchnic nerves of cats was first described in 1929 by Cannon and his associates¹¹ They used two transthoracic operations to remove the thoracic sympathetic nerves, and a transabdominal approach for the lumbar chains Experimental evidence obtained from the use of this total sympathectomy in normal dogs and in dogs with experimental hypertension^{12 13} led in 1940 to the use of the two transthoracic stages and occasionally also the abdominal stage for sympathectomy of patients with hypertension⁹ The rationale for the use of this operation has recently been reviewed^{14 15}

Fifty six patients have been treated by total thoracic and partial to total lumbar sympathectomy, splanchnicectomy, and celiac ganglionectomy The thoracic operations are carried out in two stages at intervals of two to four weeks The operative technic for transthoracic sympathectomy will be presented in some detail to aid evaluation of the complications of thoracotomy that will be discussed

Operative Technic.—The operation is performed with the patient anesthetized by ethylene and ether administered through a closed system with moderate positive pressure Intravenous saline and blood are given routinely The operation is begun by an incision over the third rib at right angles to the midaxillary line This is deepened to permit removal of 4 or 5 inches of the rib The adjacent intercostal nerve is resected and the chest is opened by dividing the periosteum and pleura of the rib bed The lung is retracted and the upper posterior wall of the thorax is exposed The pleura overlying the paravertebral sympathetic chain and the upper seven or eight sympathetic ganglia is then divided The stellate ganglion and the chain down to and including the seventh or eighth thoracic ganglia and also the upper branches of the splanchnic nerve are freed by dissection The bed of the third rib is closed by a continuous double suture of No 0 chromic catgut and reinforced by interrupted sutures approximating the divided muscles of the chest wall Stay sutures between ribs are not employed A second similar incision is then used to resect 7 inches of the tenth rib and expose the lower posterior wall of the thorax The sympathetic chain and the splanchnic nerves that were freed through the upper incision are picked up and dissected down to the level of the diaphragm The fibers of the diaphragm about the splanchnic nerve are split Traction on the splanchnic nerve brings the major portion of the celiac ganglion through the diaphragm for resection The posterior attachment or reflection of the diaphragm is partially divided transversely and the diaphragm is retracted downward and inverted The thoracic paravertebral sympathetic chain is

then picked up and dissected downward to locate and remove the first or the first and second lumbar ganglia. After the sympathetic nerves and ganglia are removed a No. 32 Pezzer catheter is usually placed through a stab wound in the midaxillary line between the eighth and ninth ribs for sterile chest drainage. The defect in the pleura of the

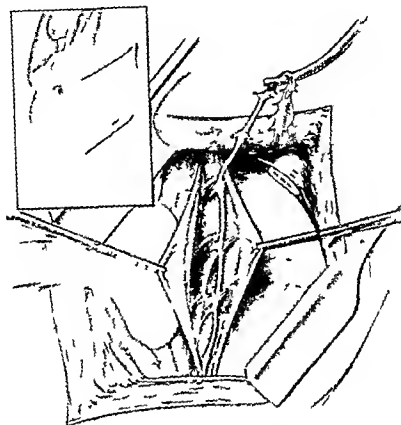


Fig. 463—Thoracotomy through the bed of the third rib for removal of the stellate and upper thoracic sympathetic chain and ganglia is illustrated. The inset shows the location of the incision and also the location of a second incision on the tenth rib used to enter the lower thorax. The stab wound for continuous sterile chest drainage is located just above the lower incision.

posterior chest wall cannot be repaired. The incision in the chest wall is finally closed using fine chromic catgut. The operation is illustrated in Figs. 463 and 464.

After operation the Pezzer catheter when employed is attached to a sterile chest suction apparatus (Fig. 465). The catheter is removed

on the third or fourth day after operation. Intranasal oxygen is usually used for twenty-four to forty-eight hours. The patients are routinely turned each hour for forty-eight hours.

One hundred and eleven thoracotomies for this type of sympathectomy were performed on fifty-six patients with hypertension. The

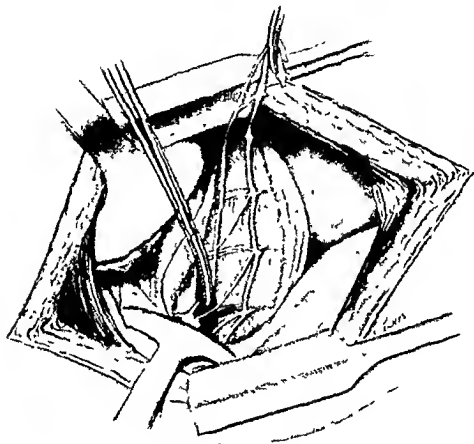


Fig 464.—The exposure of the sympathetic chain, splanchnic nerve, and celiac ganglia obtained by thoracotomy through the bed of the tenth rib is illustrated. This exposure is used for the lower part of the operation for total thoracic and partial to total lumbar sympathectomy and celiac ganglionectomy illustrated in Figure 463. It is also used for those patients in whom splanchnicectomy alone is elected.

patients and the complications that developed will be presented in two groups. The first group includes nineteen patients who were treated at the University of Chicago between May 1940 and June 1942. These nineteen will be discussed briefly since their hospital records are not now available for detailed study. Their care differed from the later group in that ultraviolet bactericidal radiation was not

used in the operating room and chemotherapy employing only sulfanilamide or sulfathiazole was less frequently employed after operation. Intratracheal intubation was not employed during anesthesia.

There were three deaths during the period of hospitalization for operation. One followed a uremia and pneumonia that developed two weeks after the first stage of the sympathectomy. Death occurred five

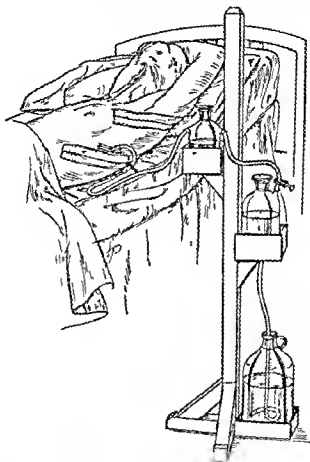


Fig. 465—The sterile gravity suction apparatus employed during the first several days after thoricotomy to minimize complications from pleural effusion is illustrated.

weeks later. Two followed a sudden arrest of respiration that occurred on the third and the fifth day respectively after the second stage. Both of these deaths occurred in patients who had had repeated episodes of hypertensive encephalopathy and also two or more cerebral vascular accidents. Autopsy revealed minimal pulmonary pathologic change. Each brain demonstrated evidence of increased intracranial

pressure and of advanced atheromatous obstructive vascular disease of the arteries of the circle of Willis. It seems probable that these two deaths from abrupt failure of respiration were caused by the lowered blood pressure and the increased intracranial pressure with resulting ischemia of the respiratory center. The three operative deaths among these first nineteen patients seem to be related directly to the hypertensive disease process and the sympathectomy and not to the thoracotomy.

Continuous sterile chest drainage was used in all but two of these nineteen patients. Serious complications related to the use of the drains did not occur.

Complications that are evidently related to the thoracotomy did occur. Superficial wound infections developed in four patients. A localized empyema developed beneath the third rib bed in one. It required secondary open drainage. Bronchitis with tenacious mucus and severe dyspnea occurred in five. This precipitated cardiac failure and acute pulmonary edema in one. Varying degrees of pleural effusion occurred in all patients. Elevation of temperature developed in many and lasted from several days to two weeks.

The second group of the fifty six patients who were treated by total thoracic and partial to total lumbar sympathectomy and celiac ganglionectomy consists of thirty seven treated in Duke Hospital since June 1942. The anesthetic and the technic of operation have not been altered. Bactericidal ultraviolet radiation as described by Hart^{16, 17} was used in the operating room during each operation. Intratracheal intubation was employed during anesthesia for the first operation in three patients, for the second in five, and for both operations in one. Intravenous saline or glucose and also blood were given during each operation. As the sympathectomy progressed, blood pressures were lowered. The reduction reached shock levels in two patients during the first operation and in twenty six during the second sympathectomy. In each instance the sympathectomy was discontinued for ten to thirty minutes to permit recovery and stabilization of pressure and then completed.

Penicillin was employed prophylactically or therapeutically in seven patients during the first several days after each operation. Sulfamerazine, sulfathiazole or sulfadiazine was given to ten patients along with penicillin and to five who did not receive penicillin. Fifteen patients did not receive penicillin or chemotherapy. The interval between the thoracotomies ranged from fourteen to seventy two days and averaged twenty four days.

Continuous sterile chest drainage was employed after each operation in all but two of the seventy four thoracotomies in these thirty seven patients. There were no complications or significant observations related to use of the drains in sixty six thoracotomies or twenty

had advanced encephalopathy resistant to medical management. It occurred nine days after the first operation with evidences of increased intracranial pressure and a cerebral vascular accident. These deaths are related to the disease and the sympathectomy rather than to the thoracotomy. Of the remaining seven patients thoracotomy was well tolerated in three as judged by a maximum elevation of temperature to less than 101°F . The remaining four developed an elevation of temperature over 101°F . Two of these developed an elevation of pulse over 110. The rate of respiration did not exceed 30 in any patient. The interval between operations ranged from thirteen to twenty three days with an average of eighteen. X ray studies of the seven patients demonstrated moderate clouding of the costophrenic angle in six and fluid sufficient to produce shift of the mediastinum in one.

Infections of the pleural cavity or of the superficial wounds did not occur. There was no clinically recognizable pneumonia. Two patients developed mucus in the trachea and cough. Four patients were given penicillin. Intratracheal intubation was employed during operations in two patients. Blood pressure was not reduced to shock levels in any patient. Abdominal distention occurred in three. Each patient complained of pain in the chest wall or upper abdomen.

Splanchnicectomy by Lumbodorsal Approach—Sixteen patients were operated upon through the posterior hockey shaped incision described by Smithwick.¹⁸ After dissecting free and retracting the heavy lumbar muscles the twelfth rib was resected and the diaphragm was detached. The sympathetic and splanchnic nerves were removed from beneath the pleura and the peritoneum. In one-half of the patients the celiac ganglia were also removed. Small openings into the pleura developed during five operations. The course of these five patients did not differ from the others. Ethylene ether anesthesia and bactericidal radiation were used during each operation and blood and intravenous fluids were routinely administered. Intratracheal intubation was employed for anesthesia in seven patients. The two stages were performed at intervals of ten to twenty eight days, the average being seventeen days. Reduction of blood pressure to shock levels occurred in six patients during the second stage of the sympathectomy.

One patient died two weeks after the first operation with uremia. The reactions of the remaining fifteen will be described. Seven tolerated operation favorably as judged by a maximum temperature of less than 101°F . Eight developed temperatures over 101°F that lasted three to fourteen days. Of these eight three developed a rate of respiration over 30 per minute. Nine of the fifteen patients developed tachycardia of more than 110. Penicillin or chemotherapy was employed in eight patients.

Two wounds disrupted and became secondarily infected. A hemat

oma occurred in another that also developed infection X-rays after operation revealed pleural effusion in all patients This was sufficient to produce a shift of the mediastinum in one Three patients developed pneumonia Two others developed bronchitis and severe cough All of the patients also complained of pain in the lower chest, in the abdomen, and occasionally around the iliac crest Abdominal distention occurred in five

TRANSTHORACIC VAGOTOMY

The operations described above have all been sympathectomies performed in patients with hypertension A transthoracic approach for resection of the lower thoracic vagus nerves and their branches has been devised by Dragstedt¹⁸ for treatment of patients with peptic ulcer The therapeutic and physiologic effects of this operation have been reviewed by Thornton, Storer and Dragstedt,¹⁹ Grimson, Taylor, Trent, Wilson and Hill,²⁰ and by Moore, Chapman, Schulz and Jones²¹ and need not be discussed in this report Vagotomy affords an opportunity to study the complications of thoracotomy in patients who have peptic ulcer and who do not have hypertension or undergo sympathectomy

Thirty three patients have been treated by vagotomy in Duke Hospital since July 1944 without mortality The operative approach is illustrated in Figure 466 Anesthesia and supportive therapy were the same as for sympathectomy except that blood transfusions were not often used Blood pressure was reduced to shock levels during operation in only one patient Sterile chest drains were arbitrarily not employed Penicillin was used in eleven patients and chemotherapy in ten Intratracheal intubation was employed during anesthesia in nine

Two of the thirty three patients had vagotomy because of tertiary lues with severe gastric crises The remaining thirty one had vagotomy because of duodenal, stoma or gastric ulcers In three instances vagotomy was performed immediately after laparotomy and gastroenterostomy and in one after exploratory laparotomy Since these procedures may have altered the postoperative course these four operations will be omitted and only the remaining twenty nine vagotomies will be included in the analysis

The thoracotomy was well tolerated in thirteen patients as judged by a maximum temperature of less than 101° F Sixteen patients had temperatures over 101° F Elevations lasted from two to ten days Nine patients had pulse rates of over 110 and seven had rates of respiration that exceeded 30 Bronchitis with accumulation of thick mucus in the trachea occurred in six patients In addition clinically recognizable pneumonia occurred in five In three it was located in the right lower lobe Accumulation of some fluid in the pleural cavity on the left side occurred in all patients In three it was sufficient to

produce shift of the mediastinum. Atelectasis was observed by x ray on five occasions. Infections of the pleural cavity or of the operative wounds did not occur. Pain on the side of the operation occurred and persisted several weeks. Abdominal distention occurred but seemed to be related to the effect of the vagotomy on the stomach rather than to the thoracotomy.



Fig. 466—Thoracotomy through the bed of the eighth or ninth rib for resection of the vagus nerves and the branches about the lower esophagus is illustrated.

COMMENT AND SUMMARY

Certain complications have developed after thoracotomy employed for sympathectomy or vagotomy. Also certain complications have occurred after the Smithwick retropleural transdiaphragmatic splenectomy. A comparison of the complications observed after the various forms of thoracotomy and an analysis of the value of certain prophylactic measures will be attempted. The complications and their prophylaxis will be summarized and discussed separately.

Infection.—Nineteen patients had thirty-seven thoracotomies performed with conventional aseptic surgical technique but without ultra violet bactericidal radiation in the operating room. Four developed superficial wound infections and one developed a localized empyema. Seventy-five patients had 119 thoracotomies performed using conventional aseptic surgical technique reinforced by ultraviolet bactericidal radiation in the operating room. One developed a wound infection and another developed a wound hematoma that became secondarily infected. Empyema did not occur. Chemotherapy was not consistently used in either series of patients. It therefore seems probable from this reduction of rate of infection that ultraviolet bactericidal radiation during operation is a useful prophylactic adjunct to thoracotomy.

Pleural Effusion.—Varying degrees of pleural effusion occurred after each of the operations described. Sterile chest drainage (Fig 465) was usually employed in thoracotomies for removal of the entire thoracic paravertebral sympathetic trunks, the splanchnic nerves, the celiac ganglion, and the upper lumbar ganglion. Drainage was arbitrarily not employed after the less extensive thoracotomies for splanchnicectomy or vagotomy. A comparison is therefore possible between the complications in thirty-seven patients or seventy-two thoracotomies performed with continuous chest drainage for the total thoracic sympathectomy and the complications in thirty-seven patients or forty-four thoracotomies performed without continuous drainage for splanchnicectomy or vagotomy. Nine of the thirty-seven patients with drainage developed temperatures over 101° F. Twenty of the thirty-seven patients without drainage developed temperatures over 101° F even though thoracentesis after operation was conventionally but not routinely employed. Among the patients with sterile chest drainage pleural effusion sufficient to cause shift of the mediastinum occurred in three in whom the drainage catheters became blocked. Clinically recognizable pneumonia did not occur. Among the patients without sterile chest drainage fluid sufficient to cause shift of the mediastinum occurred in four and clinically recognizable pneumonia in five. Routine x-rays demonstrated least accumulation of fluid in the patients with drainage except for three in whom the drain became blocked. X-rays demonstrated the greatest accumulation of fluid in the less extensive thoracotomies performed without sterile chest drainage for splanchnicectomy or vagotomy. It therefore seems probable that continuous chest drainage is a valuable prophylactic measure during the first 2 or 3 days after these varieties of thoracotomy.

It is of interest that varying degrees of pleural effusion also occurred in the patients treated by the retropleural splanchnicectomy described by Smithwick. It is possible that open thoracotomy with provision for continuous drainage may prove preferable to extensive retropleural dissection.

Embarrassment of Respiration—Embarrassment of respiration during thoracotomy has occurred only occasionally. Intratracheal intubation was employed during operation for twenty of the 156 thoracotomies. On sixteen occasions it was elected by the anesthetist before operation. On four occasions it was deemed advisable during induction of anesthesia or during operation.

Embarrassment of respiration was of greater significance after operation. Varying degrees of splinting or limitation of excursion of the chest wall occurred. This restriction of normal inspiration and expiration was partially responsible for the elevations of rate of respiration observed. Among the seventy-two thoracotomies in which incisions through the third and the tenth rib bed and sterile continuous chest drainage were employed, increase of the rate of respiration over 30 per minute occurred during the first several days after operation in nine. Among the forty-five thoracotomies in which incisions were made through one rib bed for splanchnicectomy or vagotomy, a similar increase of the rate of respiration occurred in seven. These increases of respiratory rate were related to pleural effusion or to pulmonary disease more than to limitation of motion of the chest wall. It nevertheless seems advisable that sufficient time be allowed between stages of bilateral thoracotomies to permit recovery of motion of the chest wall of the side of the first operation. The average time between the thoracotomies using two incisions was twenty-four days and between the thoracotomies using one incision for splanchnicectomy was eighteen days. It seems advisable that if complications have occurred after the first operation, the second should be deferred longer than these averages.

Embarrassment of Circulation—Embarrassment of circulation with reduction of blood pressure to shock levels occurred frequently during thoracotomies for sympathectomy. It seemed to be related to the extent of the sympathectomy and to the amount of blood lost during the operation. Lowering of blood pressure occurred during the first stage of the thirty-seven bilateral total thoracic sympathectomies in two patients and during the second stage in twenty-six. It occurred during six of the fifteen second stages of the transdiaphragmatic retropleural splanchnicectomies with their associated extensive dissection of heavy muscles of the back. It occurred in only one of the splanchnicectomies through a thoracotomy incision and in one of the vagotomies.

Embarrassment of circulation therefore does not seem to be a major complication associated with thoracotomy alone. Similarly, elevations of pulse rate after operation seem to be secondarily related to other complications of thoracotomy or to the vasomotor imbalance caused by splanchnicectomy. Tachycardia occurred least often after the more extensive and uniform total thoracic sympathectomy.

Pulmonary Complications.—Accurate determinations of the exact nature of the pulmonary complications that occurred after the 156 thoracotomies or the thirty one posterior retropleural operations for splanchnicectomy is difficult. Details of the changes in the lung were often obscured by fluid. Also chemotherapy was usually given whenever elevations of temperature were observed. This interfered with the development of diagnostic signs. Nevertheless, clinically recognizable pneumonia occurred after five of the thoracotomies. These five were in patients treated by vagotomy. Interference with the motor nerves to the stomach and regurgitation and aspiration of gastric content seems more important in these five than the thoracotomy itself. It is of interest that clinically recognizable mild pneumonia also occurred after three of the retropleural splanchnicectomies. The pneumonias all responded readily to chemotherapy.

Greater difficulty was experienced with a form of bronchitis associated with dyspnea produced by accumulation of tenacious mucus in the trachea. This occurred after total thoracic sympathectomy in seven patients, after transthoracic splanchnicectomy in two, and after vagotomy in six. It seemed to be associated with pain and splinting of the chest wall and interference with coughing. Breathing exercises, inhalation of carbon dioxide, routine turning of the patient, narcotics to relieve pain, intranasal oxygen, and forced coughing have been employed as prophylactic measures. Inhalations of steam, administration of ammonium chloride, enforced coughing with the operative site stabilized by manual pressure, and when necessary intratracheal suction through a nasal catheter manipulated into the trachea or through a bronchoscope have been employed as treatment.

It has not been possible to determine the frequency with which atelectasis has occurred. The shifts of the mediastinum described have been attributed to pleural effusion. Massive atelectasis has not developed. Varying degrees of atelectasis have certainly been responsible for some of the symptoms observed.

After thoracotomy for operations upon the sympathetic or the vagus nerves the lung that has been beneath retractors is usually compressed. As a prophylactic measure against atelectasis, positive pressure has been routinely increased toward the end of the operation to 8 or 10 cm. of water. Gentle manual massage of the compressed areas of the lung then permits re entry of air so that the dark compressed areas have a normal appearance.

The routine, prophylactic use of chemotherapy and penicillin when ever elevation of temperature was observed is probably an important factor in the decrease in incidence and severity of the pulmonary complications of thoracotomy.

Abdominal Distention.—Distention of the abdomen by gas in the stomach and intestine occurred after seven of the thoracotomies for

sympathectomy and after five of the retropleural splanchnicectomies Distention did not appear immediately after the positive pressure anesthetic It is evident that the denervation of abdominal viscera incident to the sympathectomies may temporarily interfere with normal peristalsis It is therefore not possible to determine whether the observed abdominal distention is a complication of sympathectomy or of thoracotomy

Pain.—The most distressing complication of thoracotomy from the point of view of the patient has been pain Each of the patients described in this report have had pain in the chest and many of them have also had pain referred to the abdomen or to the shoulder and arm The pain is usually most intense during the second week after operation When bilateral thoracotomies are used it shifts to the side of the last operation It usually lasts many weeks The occasional patient will complain of soreness at times as long as a year or more after thoracotomy

The pain is more intense after sympathectomy than after vagotomy Since this operation is upon nerves that contain sensory fibers the pain cannot be attributed entirely to thoracotomy Nevertheless, prophylactic measures have been attempted The intercostal nerve inferior to the incision is routinely excised or avulsed In some patients the intercostal nerves adjacent to the incision have been crushed In others they have been injected with alcohol Neither procedure has effected definite relief Salicylates, heat, diathermy and psychotherapy have all been employed as adjuncts to the use of narcotics

CONCLUSION

Thoracotomy as employed for operations upon the sympathetic and the vagus nerves has been associated with a relatively high incidence of occurrence of complications The incidence may be lowered by prophylactic measures Continuous sterile chest drainage seems to be an important precaution that should be used during the first several days after operation The complications that develop usually are not serious and can be adequately treated The evidence would indicate that thoracotomy may be employed as a relatively safe surgical procedure

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SYMPOSIUM ON GASTROINTESTINAL SURGERY

ESOPHAGOGASTROSTOMY FOR LESIONS OF THE UPPER END OF THE STOMACH AND LOWER END OF THE ESOPHAGUS

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THE operation of esophagogastrostomy for lesions of the cardiac end of the stomach and the terminal portion of the esophagus has been recognized for many years as both a desirable and feasible procedure, but only by a small group of surgeons. As evidence of this is the fact that from 1907 until 1940 only twenty successful esophagogastrostomies had been reported and these had been performed by eleven surgeons. The first such case was reported by Voeleker¹ in 1907 and from that date until 1934 four additional cases are to be found in the literature. The remaining fifteen successful operations were reported from 1934 to 1940. In the past six years this operation has gained in popularity and has been extended to include esophageal lesions as high as the upper third of this organ. At present this procedure is regarded not only as feasible but as the preferable means of dealing with certain lesions of the esophagus and cardiac portion of the stomach. Only recently Sweet² reported thirty eight cases in which esophagogastrostomy was performed. Garlock³ has reported fifty five cases and many reports of smaller series have appeared.

In the first four successful cases reported in the literature the operation was performed by means of a transabdominal approach, but in the subsequent ones a transthoracic approach was utilized. In our opinion the latter approach is the superior one and has been employed in all of our cases. Obviously the transthoracic approach must be utilized for operations upon the lesions that occur at a high level in the esophagus. The great advantage of the transthoracic approach for those lesions that lie in the cardiac end of the stomach and terminal portions of the esophagus is the wide exposure and easy access thus

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afforded. With this approach not only can all portions of the organs involved be readily exposed but the regional lymph nodes can be visualized and removed. The glands which are involved lie both within the thorax and in the abdomen beneath the diaphragm. The former cannot be removed by a transabdominal approach nor can the latter if only the thorax is entered. This point was strongly emphasized by one of us¹ in 1940 in commenting on the Torek operation. When a transthoracic route is utilized and the diaphragm is widely opened, one has before him the entire stomach and the entire thoracic esophagus, together with the lymph glands along the lesser curvature and those in the mediastinum.

As indicated above, the operation of esophagogastrostomy was originally designed for patients having lesions, chiefly carcinoma, of the cardiac portion of the stomach. Subsequently its indications were extended to include carcinoma of the lower third of the esophagus and at present it is considered the operation of choice in dealing with carcinoma of the esophagus occurring as high as the upper third. Other indications for esophagogastrostomy may be benign stricture of the esophagus, large diverticula of the esophagus occurring in the lower third, and chronic ulcer of the cardiac end of the stomach. In the latter condition considerable discussion obtains as to whether resection of the ulcer-bearing cardia and esophagogastrostomy performed with the remaining portion of the stomach is preferable to a palliative subtotal gastric resection, leaving the ulcer in situ and relying on the reduction in gastric acidity to produce healing of the ulcer. In considering this operation for ulcer of the stomach one must bear in mind that during the operation of esophagogastrostomy both vagi are of necessity sectioned. In view of recent experimental and clinical work on the effects of vagotomy it would appear that beneficial effects might well result in the way of subsequent reduction in gastric acidity. Following section of both vagi in a series of experiments² in sev-

subjected to the operation have not been evident. However, a Levin tube has been left in the stomach for several days after operation and this may be responsible for the absence of dilatation.

There are methods of treating benign stricture of the esophagus other than by an esophagogastrostomy. Among these are repeated dilatation, a short circuiting operation, and the formation of an antethoracic esophagus. However, where stricture is limited to one portion of the esophagus and is of considerable extent, resection of the involved area followed by an esophagogastrostomy may be the method of choice. Similarly, where the majority of large diverticula of the lower third of the esophagus are best managed by resection of the seg-

or by changing its direction, there are instances where resection and esophagogastrostomy are to be preferred

PREOPERATIVE PREPARATION

The one lesion for which surgery is imperative is carcinoma, and this will serve as a type lesion with which to illustrate the applicability of surgery to this anatomic area. An extensive discussion of the pathogenesis or clinical symptomatology of carcinoma of the lower esophagus and cardiac end of the stomach is outside the scope of this discussion. Certain details of these aspects of the problem, however, have sufficient therapeutic significance to warrant brief reference. The diagnosis of carcinoma of the lower esophagus and cardiac end of the stomach depends upon the history, the roentgenologic evidence of partial or complete obstruction, and the obtaining by esophagoscopy of a biopsy specimen containing carcinoma cells. Since, in this area, certain functional disturbances such as cardiospasm can and frequently do present a clinical and roentgenographic pattern indistinguishable from carcinoma, the final determining diagnostic factor has generally been considered to be esophagoscopy and biopsy. Modern surgical opinion, however, is more critical than formerly. When a positive biopsy is obtained, the diagnosis is of course established. A negative biopsy, however, does not necessarily eliminate carcinoma from consideration, particularly in early lesions of the cardia and terminal esophagus. Every thoracic surgeon has repeatedly had the experience of seeing a patient in middle or late life, in whom a diagnosis of cardiospasm has been accepted on the basis of a negative biopsy, who proved at operation to have inoperable carcinoma. We, in this clinic, share in the opinion of most surgeons familiar with this area, that, where doubt exists, exploration represents the lesser risk.

Another item of therapeutic importance in the clinical pattern presented by these patients is the development of early and profound cachexia, frequently out of all proportion to the extent or duration of the malignant process. This fact has a double significance. First, in these lesions, great loss of weight and emaciation do not constitute "prima facie" evidence of inoperability. Secondly, such profound nutritional and metabolic disturbances should, if possible, be corrected before the extensive resection and anastomosis necessary for the eradication of the malignancy is undertaken.

Largely because of the foregoing considerations, we believe that there is much to be gained in such patients by the institution of a preliminary *nutrient jejunostomy*. The operation is exceedingly simple, it can be done with local anesthesia, it is attended by practically no risk to the patient, and it affords the surgeon certain great diagnostic and therapeutic advantages. Through the short upper left rectus incision used to perform the enterostomy, it is quite easy to explore the

entire upper abdomen. The presence or absence of metastases in the liver and in the subphrenic lymphatic chains can be determined. Especially in lesions of the terminal esophagus and cardia the extent of the process can be established at least grossly. We have had several experiences in which a tumor thought to have been reasonably circumscribed was found to have spread so extensively that practically the entire posterior wall of the stomach and the greater part of the pancreas were involved. Thus by a simple operative maneuver a patient who obviously was inoperable was saved the much more extensive procedure of a wide transthoracic exploration of the thorax and abdomen. Furthermore when the diagnosis is in doubt—an occurrence most frequently encountered when the lesion is at or just below the cardiac orifice—the doubt can be largely resolved by such exploration. The entire stomach can be palpated directly and if need be visualized. By invaginating the anterior gastric wall through the diaphragmatic hiatus the surgeon can palpate the lower $1\frac{1}{2}$ to 2 inches of the terminal esophagus which is the "blind" area endoscopically and roentgenographically. It should be emphasized that, given a patient 40 years of age or older who develops obstruction at or about the gastric inlet carcinoma is the assumed diagnosis until absolutely disproved.

The basic purpose of the jejunostomy however is to provide a means of restoring the patient's nutrition to normal as rapidly as possible. At this clinic a Stamm type jejunostomy is used employing a No. 12 or No. 14 F. Pezzer catheter placed in the jejunum just beyond Treitz's ligament (6 to 10 inches). Through this the patient is fed the Scott's mixture administered slowly and more or less continuously by means of a Murphy drip. The patient himself can regulate this if there is too rapid accumulation at any one time. Supplementary vitamin therapy as well as amino acids are also given through the jejunostomy as indicated. Additional parenteral therapy can also be used of course but with the intestinal avenue available less of a burden is imposed upon the peripheral venous bed which can thereby be saved to meet whatever emergencies may arise during and after the major operative procedure.

Following the institution of the nutrient jejunostomy every effort is directed at rehabilitating the patient's entire physical economy. He is gotten out of bed immediately and is urged to spend as much time as possible walking about. Frequent studies are made of his metabolic status. As guides in evaluating the patient's condition we use the following tests: complete blood count, hemoglobin and hematocrit, serum protein, albumin globulin ratio and total blood volume, urinalysis, blood urea nitrogen and carbon dioxide combining power and the electrocardiogram as an index of his myocardial status. As soon as deficits in these spheres have been relieved rarely

a matter of more than ten days, the patient is considered to be ready for definitive surgery. Seventy-two hours preoperatively penicillin therapy (15,000 to 20,000 U every three hours) parenterally and, unless contraindications exist, sulfadiazine by the enterostomy, are started. Finally, it is very desirable that the esophagus above the obstruction be as clean as possible and empty, even of saliva, when it is opened. This is accomplished by Wangensteen suction, applied for twenty-four to forty-eight hours preoperatively if complete obstruction is present. Where the obstruction is only partial, the Levin tube is passed the morning of operation, approximately two hours before the patient goes to the operating room.

OPERATIVE PROCEDURE

Cyclopropane oxygen inhalation anesthesia by means of an intratracheal tube is used. When the patient is asleep, intravenous drips to permit the continuous and, if need be, rapid administration of blood, are placed in each internal saphenous vein. We never attempt such an operative procedure without having drawn and immediately accessible a minimum of 5 units (2500 cc) of compatible whole blood. In addition, unless a blood bank is available, we require that three or four more known compatible donors be within easy call. We prefer the use of cannulas, tied in place, to needle venipunctures. As a further safety factor, each drip has interposed at the cannula a three-way stopcock, to permit periodic clearing of the cannula and the immediately adjacent vein. The patient is then placed on his right side, with both arms extended, and strapped in position on the table with two long strips of 3 inch adhesive tape, one across his hips and the other over the left shoulder. Sandbags in front and in back buttress him in this position.

Silk sutures are employed throughout the operative procedure, except as otherwise specifically indicated.

Following careful skin preparation and draping, the skin and panniculus are incised in a long sweeping curve. When the lesion is in the terminal esophagus or at the cardia, this incision is made only slightly off the horizontal, from a point just lateral to the spine to the anterior axillary line. When greater exposure within the thorax is desired because of a lesion higher in the esophagus, the incision is curved more sharply, posteriorly, to follow the paravertebral line as high as the level of the fourth rib. The skin edges are protected with towels fastened with Michel clips. Care is taken to secure the greatest possible hemostasis with the least possible blood loss. The muscles of the lateral and posterior chest wall are divided individually and hemostasis is secured by individual control of transected vessels, rather than by mass ligation. In the longer incision referred to above, partial division of the trapezius and rhomboid major permits easy

mobilization of the scapula, with subsequent free exposure of the entire thorax. We have found the optimum level for entry into the thorax to be through the bed of the resected eighth rib. Infrequently the seventh rib may be preferable. One inch segments of the vertebral ends of the adjacent ribs above and below are also resected for mobilization. The anesthetist is given a word of warning to permit cushioning of the collapse of the lung and the pleura is incised throughout the entire length of the bed left by the resected rib. The incision is then opened widely with a mechanical retractor.

Any adhesions preventing collapse and retraction of the lung are divided and a rapid inspection of the mediastinum is carried out. The mediastinum is opened widely by incising the inferior pulmonary ligament and the pleura is reflected off the underlying esophagus. This structure is then freed from the adjacent pericardium and aorta and mobilized for 2 to 3 inches above the lesion. Care is taken to identify, so far as possible, all blood vessels, and to divide them between clamps or ligatures. Every effort is made to leave all immediately contiguous lymph nodes, and as much of the surrounding areolar tissue as possible, attached to the esophagus. Almost invariably it is necessary to include both vagi in this mobilization and in the subsequent resection. About the mobilized segment of esophagus, two or more tapes are passed to facilitate subsequent handling.

The diaphragm is now widely incised radially, from the heart laterally to the costal margin, and the gastroesophageal juncture freely mobilized. Bleeding from divided diaphragmatic vessels is controlled with transfixion sutures in preference to more easily displaced ligatures. The matter of whether or not to interrupt diaphragmatic movement is not altogether settled. In the great majority of instances a low phrenic nerve avulsion is done before the diaphragm is opened. Occasionally, however, we have felt that the elderly patient's postoperative cardiorespiratory function will be better served with a static diaphragm. In that case diaphragmatic motion is controlled for the duration of the operation by injecting the phrenic nerve with 2 per cent procaine solution.

It is now possible to survey both visually and manually the entire upper abdomen as well as the thorax. Where the lesion arises in the cardia of the stomach the amount of that organ to be removed is determined, allowing a wide margin below the malignant growth. An estimate is made also of the amount of stomach which must be mobilized to bridge the gap resulting from the resection, and to provide enough slack, so that in the subsequent anastomosis there will be no tension whatever on the suture line, even if the diaphragm is permitted to move. It is important in the retracted stomach gastrotomy, a

eventuality which must be determined before extensive alterations in the gastric circulation are instituted

The feasibility of the proposed anastomosis having been demonstrated, the stomach is mobilized. Following the greater curvature and the posterior wall, the short gastric vessels and the left gastroepiploic vessels are divided between transfixion sutures. Thus the spleen is detached from the stomach and can be displaced into the abdomen, out of the way. This dissection can be continued down the gastrocolic ligament almost to the pylorus, to the point of anastomosis between the right and left gastroepiploic vessels. Or it can be limited to any desired fraction of this distance, depending upon the length of stomach needed. Returning to the cardiac area on the lesser curvature, the left gastric artery is divided between transfixion sutures and, by the procedure just outlined, the lesser curvature is similarly mobilized. At the same time the gastrohepatic ligament is largely excised together with all regional lymph nodes. The importance of removal of lymph nodes cannot be overemphasized. Excision of every accessible regional node is indispensable for cure of the patient.

The cancer bearing portion of the canal is now excised, together with a wide margin of normal tissue on either side. If the tumor is gastric, the stomach is divided between Payr clamps well below the distal limits of the tumor. Where the tumor is well up in the esophagus, transection is carried out between long Kocher clamps at the esophagogastric juncture. In either instance the entire area is blocked out with moist pads, to minimize the risk of contamination. The inferior stump is closed over the clamp with a continuous inverting right angle suture of No 0 or No 1 chromic catgut on a swedged needle, reinforced by a row of Halsted mattress sutures of medium silk (No 000). The proximal stump having been occluded either with a simple tie or by a suture, the clamp is removed, the end of the tube is occluded with rubber protective securely tied, and the tube is temporarily displaced upward out of the immediate operative field.

The mobilized stomach is now delivered into the thorax for a distance sufficient to meet the following requirements. In the first place the superior point of division of the esophagus, and consequently the level of anastomosis, must be well above the farthest extent of the tumor. Frequently, we have asked the pathologist for an immediate frozen section of the proximal end of the resected segment, to make certain that no tumor has been left intramurally in the esophageal stump. *Secondly, there must be absolutely no tension on the anastomotic suture line.* In fact, those portions of the esophagus and stomach immediately adjacent to the anastomosis should be quite slack. Finally, there must be a sufficient length of stomach in the thorax so that subsequent closure of the diaphragm will not drag on the anastomosis. These criteria having been met, the stomach is tem

porarily anchored with interrupted sutures of medium silk to the periosteum of adjacent ribs. The anesthetist now applies positive suction to the indwelling Levin tube to make certain that the lumen of the esophagus is empty. The area is blocked out with fresh moist pads and the esophagogastric anastomosis is carried out by the following technic.

An area on the anterior surface of the stomach is chosen as the site of anastomosis and the esophagus is united to the stomach at the predetermined level by means of two guide sutures of medium silk placed at each lateral extremity of the esophagus. By this maneuver the length of the incision into the stomach can be made approximately equal to the diameter of the esophagus. The posterior half of the esophagus between the guide sutures is then united to the stomach by a layer of interrupted sutures of medium silk which penetrate the *submucosa* of both structures (Fig 467 1). This is the posterior outer layer. The stomach is now incised as previously planned, the submucosal vessels being ligated before the mucosa is opened. The esophagus is now divided (Fig 467 2). When the mucosa of the esophagus tends to retract—as not infrequently happens—two or three temporary sutures anchoring this layer to the submucosa are helpful in preventing such retraction. The free posterior lips of the incision in the stomach and of the esophageal stump are then united by a layer of interrupted sutures of silk passing through all coats of each organ, care being exercised to accomplish an accurate coaptation of the two mucosal edges (Fig 467 3). This is the inner posterior layer. At this point the Levin tube is threaded into the stomach beyond the anastomosis. The anterior lips of the anastomosis are now approximated with a row of interrupted Lembert sutures passing through the entire wall of each organ—the inner anterior layer (Fig 467 4)—and the anastomosis is completed with an outer anterior layer of interrupted sutures which include the submucosal coats (Fig 467 5). As an alternative technic we occasionally use for the entire inner through and through suture line a continuous right angle suture of catgut locked at intervals to interrupted sutures of silk. When possible a piece of omentum is brought up and tacked over the suture line to reinforce it. The temporary anchor sutures in the stomach are removed and the anastomosis is allowed to seek its own level. The stomach is then securely anchored to the periosteum of adjacent ribs and intervertebral disks in such fashion as to provide slack about the anastomosis (Fig 468). When possible it is highly desirable to anchor the esophagus in similar fashion to adjacent intervertebral disks in order to provide further insurance against tension on the suture line (Fig 468).

The diaphragm is closed by attaching it to the gastric wall with numerous interrupted sutures (Fig 468). These should be placed

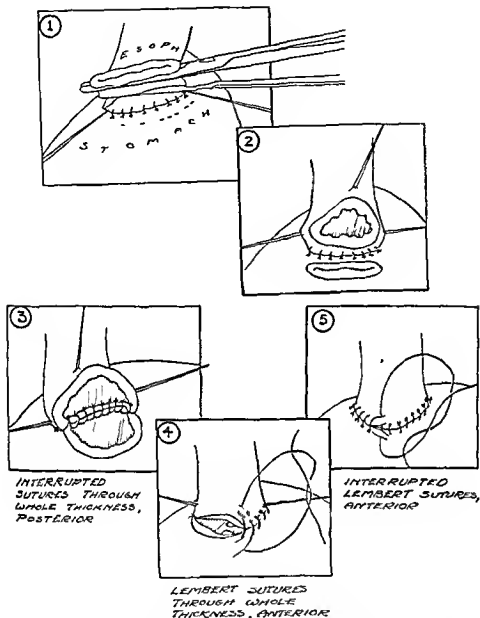


Fig 467-1, The esophagus has been resected between clamps, the proximal one of which has been left in place. A row of Lembert sutures of silk which penetrate the submucosa unite the stomach and the esophagus.

2, An incision has been made into the fundus of the stomach and the esophagus divided just proximal to the clamp.

3, Interrupted sutures of silk unite the stomach and the esophagus posteriorly. This is the second row of posterior sutures and it involves the whole thickness of the cut edges.

4, The first row of anterior sutures consists of Lembert sutures of silk and involve the whole thickness of the stomach and esophageal wall.

5, A row of Lembert sutures of silk complete the anastomosis. They involve the submucosa of both organs.

well down on the stomach to avoid subsequent drag on this organ by the diaphragm. The remaining free edges of the diaphragmatic incision are approximated with figure of 8 sutures of double medium silk care being taken to avoid constriction of the stomach by the new hiatus. Two Pezzer catheters (No 16 F) are threaded through intercostal stab wounds one anteriorly and one posteriorly and the chest wall incision is closed tightly. The ribs are approximated with four pericostal sutures of braided silk the rib bed is closed with figure of 8 sutures of double medium silk the chest wall musculature is reapproximated anatomically in layers with figure of 8 sutures and the skin is closed with interrupted sutures of fine silk.

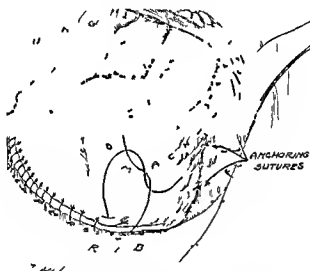


Fig 468—The anastomosis has been completed. The united organs have been allowed to retract to a level at which there is no tension and have been anchored at that point by sutures of silk. The diaphragm has been sutured well down on the stomach so as to avoid a drag on the line of anastomosis.

With the intercostal catheters open the anesthetist reinflates the left lung under positive pressure following which the catheters are clamped off and kept that way until the patient reaches his bed where they are attached to floor bottles with an underwater seal. If the right parietal pleura has been inadvertently opened as frequently happens it is imperative that the resulting pneumothorax be evacuated and the right lung completely re-expanded. For this purpose a right thoracentesis is done and the air aspirated while the anesthetist gently applies positive pressure. It is most important under such circumstances that the intratracheal tube should not be removed until the surgeon is satisfied that both lungs are fully expanded. Application of positive pressure without the intratracheal tube in place carries

the risk of inflating the stomach with resultant strain on the fresh anastomosis

A considerable amount of experimental investigation was carried out on the technic of the esophagogastrostomy by Carter, Stevenson and Abbott in 1941. These investigators performed esophagogastrostomies on fifty two dogs and concluded that the above type of anastomosis was far superior to that in which the end of the esophagus was implanted into the stomach (Fig 469), as had been advocated by Meyer,⁶ Bircher,⁷ Fischer⁸ and Bengolea.⁹ When the latter type of anastomosis was used, stricture resulted in every instance owing to the fact that the edges of the stump of the esophagus which protruded into the stomach healed together rather than sloughing away. This complication had occurred, not only in experimental animals but also in two instances in which the implant type of anastomosis had

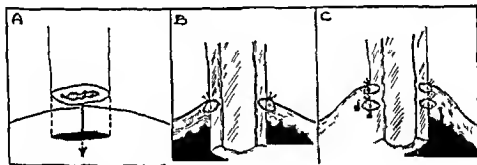


Fig 469—The implant type of anastomosis. The open end of the esophagus is introduced into the stomach. The first row of Lembert sutures of silk is shown in B and it has been inverted beneath a second row of similar sutures in C.

been performed in human cases.¹⁰ Carter and his associates¹¹ also found that *the use of anchoring sutures in the stomach and in the esophagus in order to relieve tension on the suture line is a most important technical step in the performance of an esophagogastrostomy*. When no such sutures were used the instance of perforation at the line of anastomosis was 89 per cent, when the stomach alone was anchored the instance of perforation was 29 per cent, but when both stomach and esophagus were anchored it was 0 per cent.

POSTOPERATIVE CARE

Continuous suction (Wangeosteen) without irrigation is applied to the gastric tube as soon as the patient returns to his room, and is maintained, barring contraindications, through the sixth postoperative day. Water or 5 per cent glucose in physiological saline solution is administered by the jejunostomy on the day following operation, and the Scott-Ivy mixture, augmented with amino acids and vitamins, is resumed on the second day postoperatively. Penicillin and

sulfadiazine are continued uninterruptedly postoperatively until the need for them is deemed past. Usually, one of the saphenous drps is left in place for twelve to twenty four hours after operation in order that whole blood, plasma or electrolyte solution may be given as indicated.

Whether or not oxygen should be administered is determined for the individual patient by the surgeon and anesthetist jointly. The criteria used in making this decision are the presence or absence of cyanosis or pallor, ability to maintain a clear airway, the state of the blood pressure (including pulse pressure), and the quality, rate and rhythm of the pulse. Aberrations in any of the foregoing are indications for the use of oxygen. On the other hand, the use of supplementary oxygen may lead to a slowing in the rate and reduction in the depth of respiration sufficient to induce or aggravate the serious menace of atelectasis. In elderly patients in particular, atelectasis is a frequent and dangerous complication. Every precaution is taken to prevent it, to detect its development and to relieve it. The routine use of oxygen therapy is avoided. The patient is placed in mid Fowler's position as soon as he has fully reacted from the operation and is turned from side to side hourly for the first forty eight hours postoperatively. Even thereafter he is not allowed to remain in any one position for any extended period of time. He is urged to breathe deeply and to cough at frequent intervals, and occasionally inhalations of carbon dioxide oxygen mixtures are used at intervals to stimulate deep breathing. Particularly in the immediate postoperative hours and as long thereafter as is necessary the trachea is aspirated at frequent intervals, transnasally, with mechanical suction. To facilitate the evacuation of tracheobronchial secretions we have found the repeated use of aromatic steam inhalations very helpful and, when indicated, bronchoscopy with direct aspiration of each bronchus is done.

Roentgenography on the evening of the day of operation, using a portable x ray machine, is in our opinion a wise precaution. It is especially desirable in those instances in which the right pleural space has been opened. Any residual pneumothorax may be detected and promptly evacuated, and any accumulation of fluid is aspirated dry immediately upon detection. If, in the subsequent period, there is a tendency for fluid to recur on the right side, we believe it wise to institute a closed thoracostomy. Finally, while the optimal time at which to get the patient out of bed is still somewhat controversial we prefer, subject to modification by the individual patient's recuperative powers, early ambulation (fifth to seventh day) whenever possible.

Due attention is paid to the patient's cardiovascular renal status. We prefer to have at least one electrocardiographic tracing, periodic blood urea nitrogen determinations, and a daily urinalysis in the post

operative period. Blood cell counts, hemoglobin determination and hematocrit readings are obtained every day during the first week postoperatively, and indicated therapy is promptly carried out.

On the seventh postoperative day the patient is given 1 ounce of water by mouth hourly, with the gastric suction tube open. Chest pain, temperature and pulse rise, failure of the water to return through the gastric tube or the appearance of the water in the thoracostomy tubes are all strongly suggestive of a leak in the anastomosis. Should such unpleasant signs develop, the oral feedings are discontinued for three or four days. If, however, all is well at the end of twenty-four hours the gastric tube is clamped off but left in place, and the hourly ounce of water by mouth continued. At the end of another twenty-four hours the tube is removed and during the next week the patient is advanced as rapidly as possible through a gastrectomy diet. Simultaneously, the jejunostomy feedings are progressively discontinued and the jejunostomy tube removed by simply pulling it out. The wound heals spontaneously within three days to a week. Provided there is no drainage the thoracostomy tubes are removed on the ninth or tenth day. Before the patient leaves the hospital we have found it instructive to have an x-ray visualization of the upper gastrointestinal tract with thin barium.

REPORT OF A CASE

The following is the case report of a patient recently seen, illustrating a specific application of the foregoing discussion.

CASE 45-9035 JH—Mr. J. C., a patient of Dr. Nathan Kursban, was a 69-year-old white farmer who was admitted to the hospital on December 19, 1945, because of inability to swallow even liquids. The patient's troubles with regurgitation of ingested food were of six to seven years' duration and had been ascribed to a diaphragmatic hiatus hernia for which he had refused to be operated upon. During the year preceding hospitalization, however, swallowing had grown progressively more difficult and on the day before admission to the hospital he was unable to swallow even water. The patient weighed 137 pounds and was said by his family to have lost "a considerable amount of weight" in the preceding year.

Physical examination contributed little of significance. The patient carried his years well. There was evident recent weight loss of moderate degree. The lungs were moderately emphysematous but otherwise clear. The heart was not remarkable. There was no evidence of palpable metastases in the peripheral lymph nodes or in the liver. Blood pressure was 194/84, pulse 90 and regular. Temperature 99° F. Laboratory studies: hemoglobin 6.8 gm., red blood cells 4,200,000, white blood cells 6,800, differential normal but with marked hypochromia, anisocytosis and poikilocytosis of the red cells, serum protein 5.82 mg., urinalysis not remarkable, blood urea nitrogen 14 mg., electrocardiograms (2) failed to demonstrate any abnormality.

Roentgenographic visualization of the upper gastrointestinal tract with a barium meal was reported as follows: "There is a definite constriction (in the esophagus) about 2 inches long, just distal to the midpoint. The upper end is cone shaped and the constricted portion fairly regular and smooth. The stomach and duodenum

were in normal position and were of normal size and shape except for some spasm and an apparently inconstant irregularity of the duodenal bulb. On December 22, 1945, esophagoscopy was performed under pontocaine topical anesthesia and at a distance of 13 inches from the incisor teeth an obstruction was encountered in the form of a fungating ulcerated necrotic bleeding mass from which sections were removed for biopsy. These were reported by the pathologist as epidermoid carcinoma of the esophagus. On December 26, 1945, a nutrient jejunostomy was established. Examination of the liver and upper abdomen failed to reveal any evidence of metastases in this vicinity.

After adequate preparation the patient was explored transthoracically on January 5, 1946, and the obstructing lesion identified. There was no evidence of lymphatic involvement within the thorax. The patient had the previously described hiatus hernia together with a congenitally short esophagus so that the stomach extended into the chest for a distance of about 2 inches. The aforementioned constricting mass in the esophagus lay about 1 inch above the esophagogastric junction thus placing it roughly 2 inches below the inferior border of the aortic arch. The phrenic nerve was anesthetized with 3 cc of 2 per cent procaine immobilizing the diaphragm which was then opened widely. A survey of the upper abdomen confirmed the findings at the time the jejunostomy was established. Utilizing the technique described heretofore the stomach was mobilized and the gastrohepatic ligament excised. The cancer bearing portion of the esophagus was resected and an esophagogastrostomy carried out just below the arch of the aorta.

Postoperatively the patient did exceedingly well. He had a rectal temperature of 103° F for two days postoperatively following which it dropped to 100° to 101° F with a commensurate pulse. On the ninth postoperative day the patient was given water by mouth 1 ounce hourly but after the second ounce of water he experienced a pain radiating across his left chest followed shortly by a chill and a temperature rise to 104° F. Oral feedings were discontinued immediately. There was considerable question as to the cause of this episode. Among other things due consideration was given to the fact that the patient had been receiving penicillin for nine days. This was discontinued and his temperature gradually subsided to normal. Water by mouth was again started on the fifteenth postoperative day and was continued without untoward incident. The nasal tube was removed on the seventeenth day and oral feedings advanced while jejunostomy feedings were gradually discontinued. The patient was gotten out of bed on the seventeenth postoperative day and the jejunostomy tube was removed on the twenty third postoperative day. He was discharged on the twenty fifth postoperative day. Visualization of the reconstructed esophagus with a barium meal just prior to discharge revealed a completely patent esophagogastrostomy.

The patient has been seen repeatedly since discharge and on the last occasion prior to this report which was four months postoperatively was doing very well. He had gained 20 pounds in weight was eating everything without difficulty and had regained his strength sufficiently to drive his own car for a distance of 50 miles from his home to the clinic.

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THE SURGICAL TREATMENT OF BLEEDING PEPTIC ULCER

M M ZINNINGER, M D, F A C S *

THE surgical treatment of bleeding peptic ulcer is far from standardized and marked differences of opinion exist as to the best method of treating this complication. In general, it is agreed by surgeons that a patient with an ulcer which has caused severe, recurrent hemorrhage should be treated by operation in an interval after bleeding has ceased and the patient has recovered from the effects of loss of blood. This is particularly indicated when other symptoms of ulcer are present such as pain or vomiting. Ideally, the operation in such cases consists of excision of the ulcer with partial gastrectomy.⁶ While such a procedure does not remove permanently all possibility of future bleeding it does reduce both the likelihood of its occurrence and its seriousness if it does occur. That operation should be performed in such cases is indicated by the well established fact that the mortality from bleeding ulcer increases with repeated hemorrhages and with the age of the patient.

Regarding surgical intervention during the bleeding episode there is considerable disagreement. In spite of reduction in mortality in recent years as a result of improvement in conservative or non-operative treatment it is well known that some patients still bleed to death from their ulcers and the question naturally arises as to whether some of these deaths could not have been prevented by an operation consisting of ligation of the vessel or vessels or resection of the ulcer during the episode of bleeding. It has been clearly established that this can be done in some cases in which the surgeon has been willing to operate on an almost exsanguinated patient. It seems almost equally obvious that, if this method were used in a large percentage of all cases with bleeding, a fair number of the patients would succumb to the operative procedure. As a matter of fact, it is generally stated that the mortality rate is higher with operative than with non-operative treatment. It must be recalled, however, that the statistics quoted in support of such a statement usually will not stand critical analysis for they often represent the operative mortality of patients who have failed to respond to nonoperative treatment and are

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operated upon as a last resort. They cannot in fairness be compared with the whole group of nonoperated patients. It is interesting to note that those who most vigorously oppose operative treatment are often those who have given it inadequate trial.

If it were possible to predict with any degree of certainty at the beginning of an episode of bleeding which patients would cease bleeding and recover, and which would bleed until death ensued, it would then be possible to operate only on the latter group, early in the course of bleeding, with the confident expectation that in some of them the bleeding could be stopped and the life of the patient saved. Unfortunately it is not possible at the present time to be sure what the outcome of an episode of bleeding will be, and therefore it becomes necessary to arrive at the best estimate possible on the basis of certain information plus past experience with other cases.

DIAGNOSIS

When one speaks of bleeding from ulcer, there is generally implied a hemorrhage of some magnitude, sufficient to cause rather striking clinical symptoms. These symptoms and signs vary somewhat depending on the amount and rapidity of blood loss, but in general consist of a feeling of weakness, dizziness or faintness, with rapid, weak pulse and often other signs of shock. There may be nausea with vomiting of bright red blood, or blood tinged fluid, the amount of which is usually overestimated by the patient or the patient's family. Often, also, there is urgency of defecation which occurs at about the same time as the vomiting. Not infrequently the patient may actually faint during or following the attack of bleeding. The stools may be tarry for a period of days thereafter, while in very rare instances recognizable red blood may pass in the stools during the bleeding episode. Symptoms such as those just described, occurring in a patient with known gastric or duodenal ulcer, are sufficient to justify the assumption that the bleeding is coming from the ulcer. In a general hospital practice, however, in which patients present themselves with such signs of internal hemorrhage but without any record or history of their preceding physical status, the question of the origin or site of the bleeding may present a major diagnostic problem. Often the patient is too ill for careful history taking or complete and thorough examination.

The most frequent cause of serious bleeding into the upper gastrointestinal tract which may be confused with bleeding peptic ulcer is undoubtedly rupture of esophageal varices which are secondary to cirrhosis of the liver or portal hypertension. Other common causes are diffuse gastritis with oozing from the mucosa, bleeding carcinoma or benign tumor, hemorrhagic disease, and aneurysm eroding into the esophagus or duodenum.

When a patient is seen with vomiting of blood and the signs and symptoms of bleeding into the upper gastroenteric tract such as have just been described, but about whom no previous history is available these possible causes should be considered and an attempt made to establish the true diagnosis. One might try first to elicit a history from the patient or his family of the known presence of an ulcer, or a story suggestive of ulcer. If this is negative, the next attempt probably would be to look for evidence of cirrhosis of the liver such as mild jaundice, spider angiomas, enlarged liver and spleen, dilated abdominal veins and the like. In addition to routine blood studies, determinations of the prothrombin time and blood urea nitrogen should be made. If the patient is in shock, a transfusion of whole blood should be given slowly. Further studies may then be indicated. These might include fluoroscopy to determine the presence of an aortic aneurysm, an attempt to demonstrate esophageal varices by the Valsalva technic and study of the stomach and duodenum by the Hampton technic.¹ Although one does not elect to make these studies with a very ill patient, one should not hesitate if the need for differential diagnosis seems to be sufficiently important. We have never seen harm come from a carefully performed examination of this sort, while on several occasions bleeding has ceased after barium study, and for this reason we do not regard the examination as hazardous. Many times an ulcer which has only been suspected, has been demonstrated by barium study, though at times incorrect information has been reported. Failure of correct findings is inherent in the procedure, which is limited in its application but if these limitations are appreciated it may at times prove very helpful. The most frequent sources of error have been reporting the presence of duodenal ulcer when one did not exist, and failure to demonstrate a gastric ulcer which was subsequently proved to be present.

CRITERIA FOR OPERATION

If ulcer is shown to be present as a result of these studies, or if it is known to be present as a result of previous knowledge of the patient, it is my belief that the question of prompt operation should now be considered. The decision for or against operation needs to be carefully judged in each individual case. If the bleeding is moderate and if it apparently ceases promptly, the patient is watched and treated by nonoperative measures. However, if the bleeding is massive, if it apparently continues or recurs shortly after having once stopped, and particularly if the patient is in the older age group (i.e. 60 years of age or older) operation should be performed after adequate blood transfusion.

Before considering in detail the criteria we use for determining whether operation should be performed, it would be well to review

some of the important pathologic aspects of bleeding ulcer. Perhaps the most frequent site for bleeding ulcer is the posterior wall of the first portion of the duodenum, the ulcer having eroded one of the branches of the pancreaticoduodenal artery. If the gross specimen is examined, there is usually found a segment of artery exposed with an opening in its side which is partly or completely plugged with a clot of blood (Fig. 470). The artery has a sclerotic wall and is held firmly in the scar tissue in the base of the ulcer. At times the artery, especially if it be small, is completely divided and the two ends can be seen, each blocked at least in part by blood clot. Whether the artery is completely or incompletely divided, it is still impossible for retraction to occur because of the fixation of the vessel or vessels in scar tissue, so that one of nature's most efficient mechanisms for stopping bleeding from an open artery cannot function, that is, retraction of

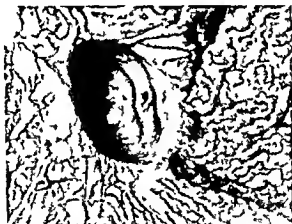


Fig. 470—Ulcer of stomach with erosion in side of artery plugged with clot
Autopsy specimen

the artery with contraction of the open end. The only way for bleeding to cease is for the blood pressure to drop and the opening in the artery to be plugged by clot. Recurrence of bleeding may develop when the clot is digested or liquefied. The ulcer may of course lie in the stomach or in the superior or anterior wall of the duodenum. In my experience ulcer of the stomach which bleeds will frequently prove to be a carcinomatous ulcer. Ulcers on the anterior wall of the duodenum seldom are the site of fatal bleeding. A number of patients on whom I have operated during a free interval after two or more previous massive hemorrhages have had an ulcer or scar of an ulcer in this location, often almost completely healed at the time of operation. Unfortunately one cannot tell from the roentgenologic appearance of a duodenal ulcer whether it is on the anterior or posterior wall, so that the fact that ulcer of the anterior wall is less likely to

2 Patients with duodenal ulcer who have previously been operated upon, and who now experience serious hemorrhage several years later. In most instances the bleeding will be from a gastrojejunal ulcer. Unless bleeding continues unchecked, conservative treatment would seem to be the method of choice in this group, as the operation is likely to be complicated and it is unlikely that it could be performed quickly or safely. However, if bleeding persists, even in this group operation may be necessary.

3 Patients who are admitted without any information available as to previous ulcer, and in whom the source of bleeding is not known. Here caution is necessary and studies to determine the source of bleeding should be instituted. If chronic penetrating ulcer can be demonstrated, I believe prompt operation is indicated.

4 Patients with bleeding in addition to some other complication such as perforation or obstruction should be operated upon promptly. The mortality in this group is high, but some patients can be saved by operation.

5 Repeated severe hemorrhages recurring in any of the above groups may make operation advisable, unless a definite diagnosis can be made that the bleeding comes from some condition other than ulcer. Failure to prove the existence of ulcer is not a contraindication to operation. The danger to life with repeated hemorrhage is greater than the risk of exploratory laparotomy.

The type of operative procedure will vary with the individual case, though excision of the ulcer with partial gastrectomy is the method of choice, if the condition of the patient permits a procedure of this magnitude. With gastric ulcer, ligation of the vessels around the ulcer from outside the stomach, may be sufficient. I have used this method successfully in two critically ill patients. With duodenal ulcer, ligations outside the bowel wall alone are insufficient, because of the intricate anastomoses and the inability to reach the vessels entering posteriorly from the pancreas. Successful control of hemorrhage in such cases may be obtained by opening the anterior wall of the duodenum and placing a deep suture of catgut through the ulcer bed around the bleeding point, followed by closure of the duodenum or resection. Bleeding from diverticula and from benign or malignant tumors usually requires resection of these lesions. In duodenal ulcer, in which exposure is exceedingly difficult or hazardous, an operation of the Devine exclusion type has been suggested, but I have had no personal experience with this method and cannot recommend it.

In general the method of management I have used is as follows. The patient is brought to the operating room with a transfusion of blood running. A tube is placed in the stomach so that fresh bleeding can be detected by suction on the tube. Cyclopropane and oxygen with or without ether by intratracheal tube is the anesthetic of choice.

An upper transverse abdominal incision is made. Inspection and palpation will usually show the location and nature of the lesion. If it is in the stomach, and there is no fresh bleeding as evidenced by blood from the tube in the stomach, a gastrectomy according to the usual technic can be carried out (Fig. 472). If the lesion is in the duodenum it is usually wise to open the duodenum and make sure that there is no active bleeding. If there is, it can usually be controlled by pressure on the bleeding point with a sponge on a clamp, by direct pressure with the finger, or by passing a deep suture. In most instances after the bleeding has been stopped, with the transfusion running, the condition of the patient improves and resection

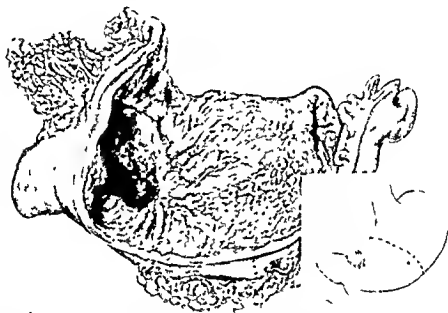


Fig 472—Drawing of specimen after resection Gastric ulcer with eroded vessel

can be carried out, the patient leaving the operating room even after several hours of operation in better condition than when he arrived. On the other hand, if the patient is not doing well, or is not improving, the duodenum is closed as soon as the bleeding is controlled and the operation is terminated as quickly as possible.

If resection is done, the base of the ulcer may have to be left in situ as a granulating wound, the duodenum being removed distal as well as proximal to it (Fig. 473). Closure of the duodenal stump may be rather difficult in such cases. If the posterior wall can be mobilized the usual closure can be used. The method I prefer is to clamp the bowel with a Kocher clamp, divide it with the cautery and obtain inversion of the crusbed end with a continuous right angle

suture of No 00 chromic catgut in two layers. If the posterior wall cannot be mobilized this may be impossible. In such instances the anterior wall should be freed as much as possible, after which a right angle continuous suture can be placed, using the scarred fibrotic pancreas for the posterior line. This usually leads to incomplete inversion and needs a row of mattress sutures of silk between the anterior duodenal wall and the scarred fibrous pancreas to secure adequate closure. It is important that a few carefully placed sutures be used rather than many poorly placed ones as a multiplicity of sutures may impair the circulation and lead to leakage. After closure of the duo-

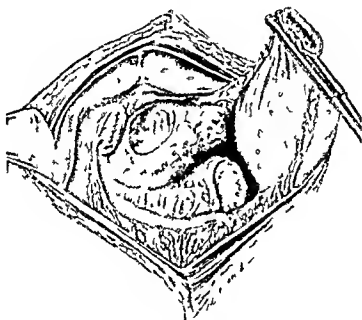


Fig. 473—Bleeding duodenal ulcer. Partial gastrectomy leaving base of ulcer on pancreas.

denal stump, resection of the stomach can be carried out in the usual fashion. If it has been necessary to leave the base of the ulcer in situ, several soft cigarette drains are placed down to it and the abdomen is closed with through and through wire sutures.⁵

If the lesion is in the stomach and bleeding is continuing, one may either ligate the vessels on the outside of the stomach or open the stomach and ligate the bleeding point from within and then proceed with resection. I have had no experience with the latter method but doubt that with it it would be very easy to accomplish satisfactory control of the bleeding.

In case laparotomy is done when neither ulcer nor tumor is present, the surgeon may be in doubt as to how to proceed. The first thing to do is to feel for any abnormalities. If none are found, the bowel should be carefully inspected to determine the highest level at which blood can be seen in the lumen through the wall as evidenced by a purplish blue appearance. If this is not helpful in locating the lesion, the stomach may be opened to see if there is blood in its lumen and to inspect and palpate its mucosa as well as that of the first portion of the duodenum. There may be found diffuse oozing from the gastric mucosa, evidence of an acute gastritis. In such an instance closure of the stomach and abdomen should probably be done although some surgeons have recommended partial gastrectomy for this condition. In most instances in which nothing abnormal can be felt from outside the stomach or duodenum, it is unlikely that much valuable additional information will be obtained from opening the stomach. On two such occasions I have closed the abdomen without exploratory incision into the stomach. Both patients ceased bleeding. One remained well but the other subsequently had another hemorrhage and died. At autopsy the site of bleeding could not be demonstrated.

CASE REPORTS

Brief histories of a few cases of bleeding which I have seen during the past five years will serve to emphasize some of the points.

CASE I—A white woman, 62 years of age, was admitted to the hospital for roentgenologic study of presumed ulcer of the duodenum. The x-ray examination showed a deep chronic ulcer of the duodenum. Twelve hours later she suddenly had a massive gastric hemorrhage. She was seen by a surgeon in consultation and, since the bleeding had stopped, he recommended transfusion and watching. About twenty hours later she began bleeding again. I was asked to see her at this time but found her pulseless when I reached the hospital. She died twenty minutes later. Postmortem examination showed a chronic duodenal ulcer penetrating into the head of the pancreas with erosion of the pancreaticoduodenal artery.

CASE II—A white man, 65 years of age, was admitted to the hospital for pain in the abdomen and vomiting. X-ray showed gastric retention and ulcer of the duodenum. He was treated by Sippy diet with gastric drainage twice daily. Because of only moderate improvement operation was decided upon and was scheduled for the following week. Three days before the date set for operation he suddenly had a massive hemorrhage. Fainting and shock developed. A transfusion was given. About four hours later he bled again and it was thought that he probably would bleed to death. However, the bleeding ceased again and operation was done several hours later as an emergency procedure. He was a large man weighing nearly 200 pounds and exposure was difficult. A huge ulcer crater was found in the head of the pancreas. There was apparently no bleeding when the operation was started. The anterior wall of the duodenum was incised and the lumen was found to be filled with blood clot. As this clot was pulled out there was a sudden gush of fresh blood from the ulcer. The bleeding was stopped by pressure first with the finger, then with a ring forceps. While the forceps was

held in place two deep sutures of No. 0 chromic catgut were placed in the pancreas one above and the other below the bleeding point. When these were tied the bleeding was controlled. Resection was then done. The duodenal stump was difficult to close but was fairly well secured. Drains were placed to the base of the ulcer which was left in situ and the abdominal wound was closed with silver wire.

The patient developed a little duodenal leakage and a pancreatic fistula both of which healed spontaneously. He left the hospital apparently well about one month later.

CASE III—A white woman 68 years of age was admitted to the hospital because of repeated gastric hemorrhage. She was under treatment for duodenal ulcer. She had had two operations about twenty five years before, the exact nature of which was not certain but one was said to have been a pyloroplasty for duodenal ulcer. Her last x ray had been made about six months before and showed deformity of the duodenum. Because of continued bleeding she was operated upon as soon as shock was controlled by transfusion. A firm lesion was found in the prepyloric region together with the scar of a healed duodenal ulcer. The gastric lesion was thought to be a carcinomatous ulcer and resection was done. As the dissection was carried upwards on the stomach a patent gastroenterostomy stoma was found. The stomach was amputated just distal to the stoma and the cut end closed.

Unfortunately the patient developed severe gastric bleeding about twenty four hours after operation and bled almost continuously for twenty four hours.

On postoperative day 11 the excised specimen showed adenocarcinoma. This case was a technical failure due to improper hemostasis of the cut end of the stomach.

CASE IV—A white man 57 years of age was admitted to the hospital with massive hematemesis. He was in severe shock. Transfusion was given and his condition improved. History and general physical examination were not characteristic of any particular lesion. A series of severe hematemeses occurred during the next few days. Barium studies of the esophagus, stomach and duodenum were made. Fluoroscopic examination of the chest showed some widening of the aortic shadow. There was apparently a little distortion or spasm of the esophagus. Nothing abnormal was seen in the stomach or duodenum. In spite of repeated massive hemorrhages there was no elevation of the blood urea nitrogen.

Because of the recurrent severe bleeding exploratory laparotomy was done by the resident surgeon. No ulcer, tumor or other abnormality was seen or felt. The stomach was opened and found to contain only a little blood tinged fluid. The abdomen was closed. About thirty hours later the patient had a very severe hematemesis and died in shock shortly thereafter. Autopsy showed a small aneurysm of the thoracic aorta which had perforated into the esophagus. Very little blood was found in the stomach or intestine. Apparently most of the blood had been vomited up and this fact accounted for the failure of the blood urea nitrogen to rise. This probably should have led to the conclusion that the bleeding was cephalad to the stomach. It is important to note that the exploratory laparotomy apparently did not contribute to the fatal outcome.

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THE TREATMENT OF PENETRATING WOUNDS OF THE ABDOMEN IN CIVILIAN PRACTICE

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PENETRATING wounds of the abdomen have always been associated with a very high mortality in both military and civilian surgical practice. In the wars prior to the Second World War including the Civil Spanish American Boer and Russo Japanese Wars the published mortality rates in collected series varied between 60 and 90 per cent and in World War I it was 50 to 80 per cent^{1, 2}. In the early part of World War II it remained high being approximately 50 per cent in Gordon Taylor's series³ and 47.5 per cent in Ogilvie's⁴. The reports collected from civilian practice between 1899 and 1945 show a similar high mortality varying between 30 and 80.5 per cent¹⁰.

It must be remembered that the usual treatment of these cases during the Boer and previous wars and even during the early part of the first World War consisted of nonoperative management with starvation and large doses of morphine and the majority of casualties who were operated upon died. However reports from civilian surgeons during this same period indicated that early operation was a more desirable form of treatment and this was substantiated by military surgeons during the later part of the first World War who concluded that the nonoperative treatment was a failure.

The high mortality associated with such wounds has been caused primarily by severe shock hemorrhage and peritonitis. Associated multiple wounds of the thorax genitourinary tract spinal column or head or cutaneous burns have added to the perplexity of the problem.

GENERAL CONSIDERATIONS

Although penetrating wounds of the abdomen have a low incidence in most parts of the country according to life insurance statistics they are encountered frequently as emergencies in large charity hospitals. In the Cincinnati General Hospital there have been 161 cases between January 1942 and May 1946 an average of three cases per month. The abdominal cavity usually is penetrated by wounds through the anterior lateral or posterior walls but penetration may also occur

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through the thorax, neck, perineum, buttocks, sacral area and even the thighs. The wounds may vary from small puncture wounds produced by a hatpin or icepick to extensive lacerations permitting intestinal evisceration. The causes of penetrating wounds of the abdomen vary somewhat in civilian and military practice. In civilian surgery they are usually produced by knife, icepick, low velocity pistol or rifle, and shotgun, whereas in war they are caused by high velocity rifle and machine guns, fragments of high explosive shells, grenades, bombs and bayonets. Damage to the intra-abdominal viscera varies with the velocity, size, shape and nature of the weapon, the small bowel being damaged most frequently and the solid organs, colon and stomach less frequently. Patients with lacerations of the great vessels including the aorta, vena cava and iliac or renal arteries seldom reach the civilian surgeon unless unusual opportunities are available for rapid transportation to nearby emergency hospitals.

Shock is commonly seen in penetrating wounds of the abdomen and its severity is determined primarily by the degree of hemorrhage as well as by the type of the weapon, by the location and extent of the wound, and by the multiplicity of injuries.

Hemorrhage may be of any degree from minimal to massive with early death, and the bleeding may occur in the free peritoneal cavity or in the retroperitoneal space as a hematoma. It is usually the result of perforation of one of the larger vessels of the abdomen or of laceration of a solid viscus such as the liver, spleen or kidney. In our experience it is rarely caused by damage to the vessels in the anterior abdominal wall such as the deep epigastric artery.

Infection is particularly prone to complicate this type of injury in the form of peritonitis, residual abscesses, putrefactive empyema, retroperitoneal cellulitis or wound infection. It is the result of gross contamination by escaping gastrointestinal contents and rarely by material such as soil or dirty clothing carried into the wound from without. *The severity of infection may vary with the segment of the gastrointestinal tract injured, the amount and character of the food digested before injury, the virulence of the bacterial flora, and the resistance of the patient.*

The fully distended stomach after meals or drinking is particularly vulnerable to upper abdominal or lower left thoracic wounds. Small gastric wounds, especially those located near the lesser curvature, may be followed by little spilling, whereas larger ones, particularly those near the greater curvature, may permit almost complete emptying of the stomach. Poor oral hygiene, swallowed nasal secretions, and low gastric acidity favor high bacterial contamination of the peritoneal cavity by escaping gastric contents. The effusion of contents from the lower ileum is particularly serious because of its liquid nature and the character and abundance of its bacterial flora. The contents of the

colon are normally solid or semisolid and diffuse contamination is less likely to occur from penetration of the colon. Nevertheless, the resultant infection is serious.

The infection developing after penetrating wounds of the abdomen is almost always polymicrobial, being caused by several or many different types of bacteria.²³ The ascription of the average case of peritonitis to the unaided activity of *Bacillus coli* or other single strains seems to be without sufficient justification, and the synergistic or cumulative action of the various infecting bacteria seems to be a more plausible cause. It must be remembered that the normal peritoneum possesses considerable natural powers of resistance to infection but if repeated or constant soiling occurs, such as that produced by an unrepaired perforation of the gastrointestinal tract or a leaking anastomosis, it is unable to withstand bacterial attack and a severe, usually fatal, peritonitis is the result.

The retroperitoneal tissues on the other hand seem to have very little resistance to bacterial contamination in the presence of injury. A severe form of retroperitoneal cellulitis may complicate penetrating wounds of the abdomen if adequate drainage of the retroperitoneal spaces is not carried out. It is characterized by a spreading often crepitant cellulitis of the retroperitoneal areolar tissues with the production of considerable gray necrotic slough, and profound toxemia.²⁴ The condition is often referred to as "anaerobic cellulitis" and is likewise caused by the synergistic action of the group of aerobic and anaerobic bacteria resident in the intestinal tract at the time of injury.

Infection of the abdominal operative wound may also be caused by the same group of bacteria. Its occurrence and severity are minimized by sharp dissection, protection of the wound edges with gauze during the operative procedure, gentle handling of tissues, closure by through and through silver wire sutures and adequate chemotherapy.

A severe mixed infection of the pleural cavity may complicate combined penetrating wounds of the chest and abdomen with perforation of the esophagus, stomach or intestine.²⁵ It is characterized by a progressive effusion of thin, bloody, purulent fluid often with a foul odor within the pleural cavity and signs of profound toxemia with elevated temperature, pulse and respiratory rates and a fall in the blood pressure which usually begins between the first and third days after operation.

The successful management of penetrating wounds of the abdomen consists essentially of early, surgical repair of the injuries by exploratory operation as soon as the patient's condition will permit. As in all wounds of violence, the primary purpose of surgical treatment is to save life by the alleviation of shock, arrest of hemorrhage, and the prevention or control of infection. The secondary purpose is to restore the function and appearance of the wounded parts in so far as possible.

To accomplish these objectives, adequate preoperative preparation, early and thorough operative repair, and vigilant postoperative care are necessary.

PREOPERATIVE PREPARATION

Treatment of Shock.—A sterile dressing is applied as soon as possible to all open wounds and immediate measures are taken to recognize and alleviate existing or impending shock. The effectiveness of active treatment consisting of the use of morphine, oxygen, shock position, and the intravenous injection of fluids is largely determined by the promptness with which it is instituted. Physiologic saline or glucose solutions and plasma are used until whole blood has been made available by the blood bank. In our opinion, whole blood is far superior to plasma or any other solution in the treatment of shock associated with penetrating wounds of the abdomen. This therapy is continued throughout the operative and immediate postoperative periods. Stimulants or other liquids by mouth are not given.

If the shock is due to the effects of trauma other than hemorrhage, and if the treatment is started early, active therapy is usually successful in restoring the measurements of blood pressure, pulse and body temperature to normal within three quarters to one hour.

Control of Hemorrhage.—In general every severely shocked patient with an abdominal wound should receive transfusions of whole blood, and if little or no response occurs to the injection of 2 units of blood within one hour or less, it must be assumed for practical purposes that severe hemorrhage is a major cause of the shock. Under such circumstances two and occasionally three continuous intravenous injections of whole blood are used simultaneously in an effort to supply blood at a faster rate than that at which it is lost. In this connection it should be remembered that it is wise to make at least one of the intravenous injections through the veins of the arm whenever there is a possibility of penetration of the abdominal vena cava. In this way it is usually possible to overcome the manifestations of shock sufficiently, even in severe wounds involving the major abdominal veins and some of the larger abdominal arteries, to permit anesthesia and rapid abdominal exploration for arrest of the hemorrhage and definitive operative repair. Any hemorrhage that occurs from the wound in the abdominal wall is usually controlled easily by the application of a sterile dressing applied with moderate compression.

Diagnosis of Extent of Injuries.—After treatment for shock and hemorrhage has been started, a rapid and thorough examination is necessary to determine whether the wound has penetrated or perforated the abdominal cavity and whether there are any associated injuries of the chest, head or extremities. If a wound which perforates a hollow viscus is thought to be nonpenetrating, the mistake is usually disastrous. In most instances, however, the diagnosis offers

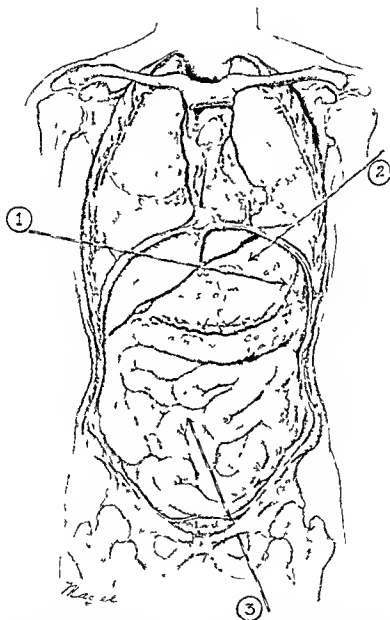


Fig 474—Semidiagrammatic and reconstructive drawing showing the anterior and lateral relations of thoracic cage to the diaphragm pleural sacs peritoneal cavity and viscera Note the vulnerability of upper abdominal viscera to penetrating injuries which first traverse the pleural sac and particularly to those which enter the chest below the fourth rib anteriorly

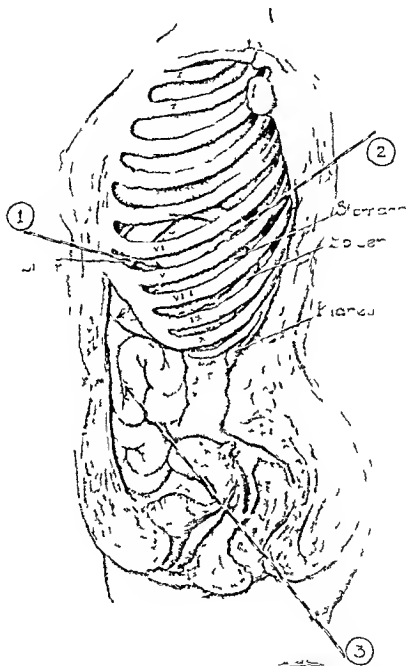


Fig 475—Semidiagrammatic left sagittal drawing through the left dome of the diaphragm which illustrates the relationship of the thoracic cage to the upper peritoneal and lower pleural cavities and which explains the frequency of combined penetration of both cavities in wounds involving the lateral and posterior aspects of the thorax and particularly those below the sixth rib posteriorly

little difficulty since a study of the history, the wound, the physical signs, and the laboratory data will usually indicate its penetrating nature. Difficulty arises particularly in tangential or oblique wounds. It must be kept in mind that it is possible for wounds originating in almost any part of the body to involve the abdominal cavity and those between the nipple line and upper thighs frequently do. Single wounds of the lower posterior and lateral aspects of the chest, particularly on the left side below the level of the sixth rib, should be regarded as thoraco abdominal until proved otherwise (Figs 474 and 475). Puncture wounds of the anterior chest wall below the level of the fourth rib may also penetrate both the pleural and peritoneal cavities. A careful study of the points of entrance and exit helps to determine the pathway of the weapon and presence of penetration. If the bullet entered the skin obliquely, an area of abrasion is evident on the proximal side of the wound and one of undermining in the subcutaneous tissue is on the distal. When there is no wound of exit, an area of tenderness or the bullet often may be palpated immediately beneath the skin at the end of the tract.

When only the abdominal wall has been injured, shock, localized tenderness and guarding may be found, but they will subside or at most remain stationary if the injury is purely parietal. If signs of peritoneal irritation develop, such as decreased respiratory movements of the abdominal wall, diffuse tenderness, rigidity, rebound tenderness, a rising pulse rate, increasing leukocytosis, and tenderness on rectal examination, the perforating nature of the injury becomes apparent. The diminution or absence of audible peristalsis on auscultation is also a very valuable diagnostic sign. The demonstration of a pneumoperitoneum by percussion of diminished liver dullness and roentgen examination signifies perforation of a hollow viscus. Occasionally injuries confined to the chest, particularly those associated with a hemothorax or fractured ribs, may present upper abdominal tenderness and rigidity, but the absence of the other signs of peritoneal irritation help in the differential diagnosis. If the signs are not conclusive of penetration it may become necessary to explore the wound, but if there is any doubt as to the penetration or nonpenetration of the abdominal cavity, laparotomy and exploration offer less over all risk to the patient than conservative management.

A specimen of urine should always be obtained immediately after admission to the hospital and examined for blood. If no urine or a small amount of bloody urine is found on catheterization, perforation of the bladder has occurred.

Chemotherapy.—Chemotherapy is indicated after any abdominal injury in which the peritoneal cavity has been soiled. We believe that the systemic administration of 3 gm of sodium sulfadiazine preoperatively by intravenous injection is of definite value. Early in our

studies sulfanilamide was instilled into the peritoneal cavity and operative wound at the completion of the operation, but we have abandoned this practice in favor of the preoperative systemic administration of sulfadiazine. Our *in vitro* studies indicate that sulfadiazine is preferable to penicillin in the mixed gram negative and gram positive flora of intestinal organisms and our clinical experience seems to bear this out. More recently systemic sulfadiazine and penicillin have been used concurrently.

EARLY OPERATIVE TREATMENT

It is imperative that the patient with a penetrating wound of the abdomen be operated upon as soon as his general condition will permit. Early operation within six hours of the time of injury is desirable and will result in a lower incidence of peritonitis. Throughout the operative procedure the transfusion of blood is continued as a safety measure. The treatment of other wounds which often accompany the main abdominal one requires judgment, but in general they assume secondary importance and are treated expectantly for the time being.

Anesthesia—Operation is usually performed under inhalation gas and ether or cyclopropane anesthesia. Intubation is desirable particularly in upper abdominal injuries, and inhalation anesthesia under positive pressure may be required in associated thoracic wounds. Local and spinal anesthesia have not been practical at the Cincinnati General Hospital because so many of the patients with penetrating wounds of the abdomen are intoxicated and unruly.

Skin Preparation—Preparation of the abdominal wall is carried out usually after the induction of anesthesia. If any viscera protrude through the penetrating wound they are gently but thoroughly irrigated with a solution of physiologic sodium chloride and covered with sterile gauze. The abdominal skin up to the edge of the wound is then washed thoroughly with soap and water, painted with a skin disinfectant, and prepared for incision with sterile drapes.

Incision—If the wound of entrance or exit is large it is usually debrided and extended in a transverse or vertical direction for exploration. If the wound is small it is usually disregarded and a separate vertical left or right rectus incision is made. In any event a sufficiently large incision should be made to permit maximum exposure. The incision is made on the right side in most instances which gives ample exposure for exploration of the entire contents of the abdominal cavity. In many of the thoraco abdominal wounds the exposure has been limited and the technical procedure difficult through abdominal incisions. Military experience in the past war has demonstrated clearly the superiority of the thoracic approach for many of the high penetrating wounds of the chest and abdomen, particularly those involving the left upper quadrant.

Arrest of Hemorrhage.—When the abdomen is opened the immediate consideration is the arrest of hemorrhage which may have been increased by the induction of anesthesia and by the release of pressure. The removal of clots and liquid blood by mechanical suction aids in the recognition of the bleeding points. The blind application of clamps in a pool of blood may be disastrous and the surgeon unaccustomed to emergency surgery may become confused and lose valuable time at this point. Hemorrhage from many bleeding vessels may be temporarily controlled by digital compression. In the upper abdomen, compression of the portal vein, hepatic artery, or coeliac axis between the thumb and a finger inserted through the foramen of Winslow may help greatly in the control of bleeding.

Damage to the spleen is usually treated by splenectomy since attempts at repair are usually futile, wasting both time and blood. In the case of lacerations of the liver, persistent bleeding may be controlled by suture of the laceration, or in rare instances by packing. However, packing with gauze should be avoided whenever possible since it may be followed by infection and secondary hemorrhage. The use of gelatin sponge promises to aid in the control of this type of hemorrhage. Detached and devitalized portions of liver should be removed and a drain placed down to the wound to permit the escape of bile.

After the arrest of major hemorrhage, a delay of several or more minutes while the transfusion of blood is being continued may be followed by a prompt rise in blood pressure and general improvement of the patient's condition.

Suture of Perforations of Diaphragm.—The necessity for early recognition and closure by suture of all perforations of the diaphragm cannot be overemphasized. It minimizes pleural contamination and the danger of developing severe pleural infections, massive pneumothorax or herniation of the abdominal contents. A sucking wound of the thorax may be produced as soon as the abdominal cavity is opened and such wounds should be repaired immediately followed by aspiration of air and contaminated blood from the pleural cavity. If a perforation of the diaphragm is not sutured, a serious and often fatal putrid empyema may develop postoperatively.

Location and Repair of Injuries.—In order to locate every wound it is necessary to examine thoroughly and systematically all of the abdominal contents. Demonstration of the points of entrance and exit through the peritoneum suggests the possible viscera damaged by the injury. Every section of the gastrointestinal tract must be demonstrated and carefully inspected for perforation. To do this, it is necessary to "run" the bowel and inspect the tract from the lower portion of the esophagus to the rectum replacing the loops of intestine immediately after inspection. In general the points of gastrointestinal per-

foration are easily recognized by the exposure and eversion of the punctured mucosa, the visible escape of gas and fluid, the dark brown or black discoloration of the adjacent tissues, the presence of food or feces in the peritoneal cavity or the presence of crepitation in retroperitoneal hematomas about the colon. If one perforation into the free peritoneal cavity is missed, the outcome is almost invariably fatal. The penetrating wounds most often overlooked are tangential ones located at the junction of the mesentery with the small intestine, those along the retroperitoneal surface of the transverse colon, rectum, pelvic portion of the colon or duodenum, and those of the posterior

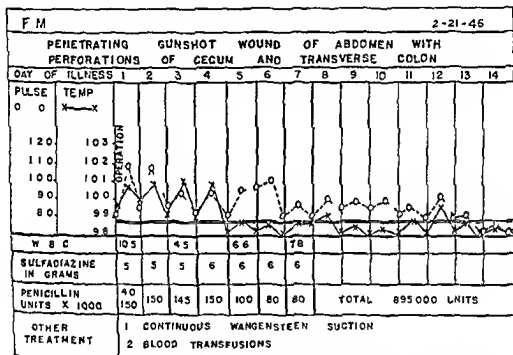


Fig 476—Chart showing the clinical course of a patient with penetrating gunshot wound of the transverse and ascending colon who was treated by early closure of the perforations without exteriorization of the colon

aspect of the stomach. In both the large and small intestine, hematomas in the mesentery may hide perforations in the mesenteric border.

All perforation of the gastrointestinal tract must be closed and most of them can be repaired by inverting Lembert or mattress sutures of fine black silk rather than by resection. When resection is necessary in more extensive wounds, primary anastomosis is preferred to exteriorization in civilian practice and it is usually done by the closed end to end method over Kocher or Stone clamps using fine black silk for suture material. At the Cincinnati General Hospital, injuries of the large bowel have also been treated with good results in the same way.

as those of the small bowel without attempt to exteriorize them (Fig 476)

Wounds of the rectum should be repaired whenever possible and thoroughly drained. A proximal colostomy should never be omitted in wounds of the rectum, however trivial they may appear to be. A left inguinal colostomy is usually desirable, but when it is evident that mobilization of the rectum will be required for any subsequent repair, a transverse colostomy is advisable to facilitate this.

A careful inspection must be made for injuries of the other retroperitoneal structures which may be concealed by a hematoma. If



Fig 477—Illustrating the appearance of the wound closed ten days previously with through and through silver wire sutures. The contaminated retroperitoneal tissues had been drained through the right flank wound and two "cigarette" drains have just been removed. Note the absence of infection in the operative wound.

be exposed transabdominally lateral to the ascending colon of the bowel and its lumen may be sutured but wounds of the kidney with active hemorrhage or severe fragmentation are best treated by nephrectomy after making sure that a second good kidney is present.

Perforations of the bladder should be sutured in layers followed by cystostomy or insertion of a retention catheter. Wounds of the ureter must be detected and repaired, preferably over ureteral catheters.

Before closure, particles of feces, shotgun wadding, pieces of food, detached portions of viscera, accessible projectiles, bits of clothing,

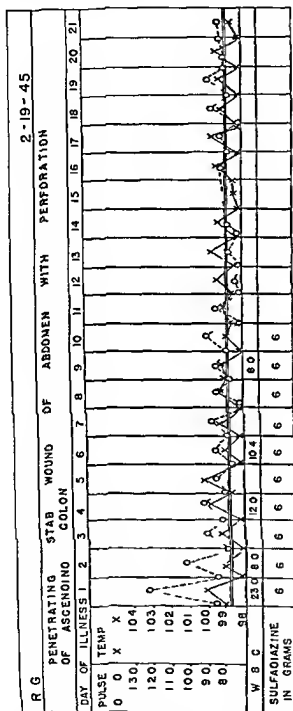


Fig 478 -Chart illustrating the clinical course of a patient with a penetrating wound of the abdomen and perforation of the ascending colon under treatment by systemic sulfadiazine in addition to early operative closure of the perforation (Solid line, temperature, broken line, pulse)

fragments of bone, sponges used for exposure or hemostasis, and liquid or clotted blood are removed from the peritoneal cavity Bul

lets not readily accessible are not removed. Lavage is not done. The use of postoperative drainage is a matter of judgment and depends upon a number of factors. In most cases drainage of the peritoneal cavity is considered useless unless there is considerable damage to structures such as the pancreas, liver or biliary tract. On the other hand contaminated retroperitoneal tissues should be drained through a stab wound in the flank after closure of the peritoneal wound (Fig 477).

Chemotherapy—We have discontinued the local instillation of sulfanilamide into the peritoneal cavity for the prevention or control of infection and prefer to depend upon the preoperative and postoperative administration of sulfadiazine systemically for the control or prevention of infection (Fig 478). Penicillin may be used in conjunction with sulfadiazine giving 15 000 to 20 000 units every three hours (Fig 476).

Wound Closure—At the Cincinnati General Hospital the wound is closed with through and through silver or steel wire sutures according to the method described by Reid and Zininger^{25, 26}. This method of closure (Fig 477) seems to be ideally suited to these cases and it has been used almost routinely at the Cincinnati General Hospital during the past thirteen years. The advantages of this method are:

- 1 Rapid closure of the wound even under difficulties arising from unsatisfactory anesthesia

- 2 Secure closure which is affected relatively little by infection or slough of the fascia; the incidence of disruption is minimal with this method

- 3 Closure of contaminated abdominal wounds without burying suture material which predisposes to more benign wound healing and reduces the liability of infection

- 4 Easy reopening of the incision by untwisting the wires if a second operation becomes necessary shortly after the original one for delayed hemorrhage or obstruction

- 5 Incidence of postoperative ventral hernia is not greater than in more formal types of closure

POSTOPERATIVE CARE

After operation the patient is returned to his bed and placed in semi-Fowler's position which aids in the localization of intra-abdominal infection. General supportive measures are continued immediately after operation and fluids by mouth are withheld. Adequate parenteral fluids are given to maintain positive water and electrolyte balance and a urinary output in excess of 1000 cc per day. Blood and plasma transfusions are also given postoperatively as indicated. Continuous gastric suction is maintained by Wangenstein's method until active peristalsis returns and gastric retention ceases. The de-

compression afforded by the immediate use of gastric suction tends to place the bowel at rest and to prevent gastric and intestinal distention resulting from postoperative ileus. Repeated auscultations of the abdomen usually show a return of peristaltic sounds on the second postoperative day. If there is any question of the adequacy of peristalsis, it may be tested by aspirating for gastric residual after the patient has been allowed to drink one ounce of water every one half hour for five or six hours with the tube clamped off. If the residual is less than two ounces, it may be safely assumed that peristalsis is adequate and fluids by mouth may be started. If more than three ounces, it is usually wiser to leave the tube in another day and repeat the test.

Chemotherapy by the systemic administration of 3 gm of sulfadiazine subcutaneously every twelve hours is continued until it can be given by mouth in doses of 1 gm every four hours, being carefully controlled by the usual means for early detection of toxicity. The blood levels are measured daily or every other day and the dose is adjusted to maintain a blood level of 6 to 10 mg per cent. It is our impression that the intelligent use of sulfonamides has been largely responsible for the elimination of peritonitis as a major cause of death in penetrating wounds of the abdomen. Penicillin may also be given parenterally in conjunction with sulfadiazine, injecting 15,000 to 20,000 units every three hours intramuscularly.

Vigilance is necessary to detect the presence of various complications which are prone to occur during the postoperative period and which must be treated as they develop. The most common ones in our experience include pulmonary atelectasis, pneumonia, pleural empyema, wound infection, intra-abdominal abscess, peritonitis, hemothorax, delirium tremens, intestinal obstruction, retroperitoneal cellulitis and thrombophlebitis. Dehiscence did not occur in any of the wounds closed by the method described and wound infections were decreased in frequency and severity.

An analysis of 161 consecutive cases of penetrating wounds of the abdomen or chest and abdomen in which the patients were admitted to the Receiving Ward of the Cincinnati General Hospital between January 1942 and May 1946 is of interest. Three of these patients were moribund on admission and died within forty-five minutes in the receiving ward as a result of severe hemorrhage. Two others died on the operating table also as the result of exsanguinating hemorrhage. In the remaining 156, there were eighteen deaths, giving a mortality rate of 11.5 per cent for those cases which survived long enough to be operated upon. For all cases admitted including those in which death occurred within ten minutes after the patient's arrival at the hospital the overall mortality rate was 14.2 per cent.

There were thirty-four thoraco-abdominal wounds in this series.

with nine deaths, or a mortality rate of 26.4 per cent which emphasizes again the severity of this type of injury and suggests the possibility that the thoracic approach might be used to greater advantage.

The causes of death and their incidence in this series are shown in Table I. Hemorrhage with severe shock was responsible for 30.4 per cent of the deaths, and pneumonia and acute putrefactive empyema were the next most important causes. In later cases it has been possible to control the putrefactive empyema by routinely closing all perforations of the diaphragm at the time of operation, by early diagnosis, and by drainage either by repeated aspirations or preferably by thoracotomy used in conjunction with the local injection of penicillin and the systemic administration of sulfadiazine and penicillin.

TABLE 1—COMPARISON OF THE INCIDENCE OF THE CAUSES OF DEATH IN PENETRATING WOUNDS OF THE ABDOMEN BEFORE AND AFTER CHEMOTHERAPY

104 Cases Admitted between January 1938 and January 1942		161 Cases Admitted between January 1942 and May 1946	
Cause of Death	No. Cases	Cause of Death	No. Cases
Peritonitis	9 (31.0%)	Hemorrhage	7 (30.4%)
Hemorrhage	7 (26.1%)	Shock	4 (17.4%)
Shock	6	Pneumonia	2 (8.7%)
Pneumonia	5	Uremia	2 (8.7%)
Uremia	1	Retropertoneal cellulitis	1 (4.3%)
Retropertoneal cellulitis	1 (0.4%)	Undetermined	1 (4.3%)

If the diagnosis is confused with postoperative pneumonia and drainage is not instituted, the infection progresses rapidly and soon produces a severe state of toxemia. Figure 479 shows the charted course of a penetrating wound of the abdomen which developed a fatal putrefactive empyema. In this case the perforation of the diaphragm had not been sutured, the diagnosis was delayed, drainage by thoracotomy was too late, and chemotherapy with penicillin was not given.

Significantly, peritonitis was a contributing cause of death in only two instances, and these were due to a perforation of the duodenum which was overlooked in one case, and to a leaking suture line of the duodenum in the other. Thus, peritonitis was largely eliminated as a cause of death, apparently by the use of adequate chemotherapy with systemic sulfadiazine or penicillin and sulfadiazine used in conjunction with early operative repair of all perforations.

In contrast, a study of 104 cases with penetrating wounds of the abdomen treated without chemotherapy in the four years preceding

January 1942 at the Cincinnati General Hospital showed that the mortality rate was 27.9 per cent. Significantly, generalized peritonitis was responsible for 31 per cent of the deaths (Table 1). A comparison of the incidence of the causes of death in the two series indicates that several changes have occurred since the advent of chemotherapy.

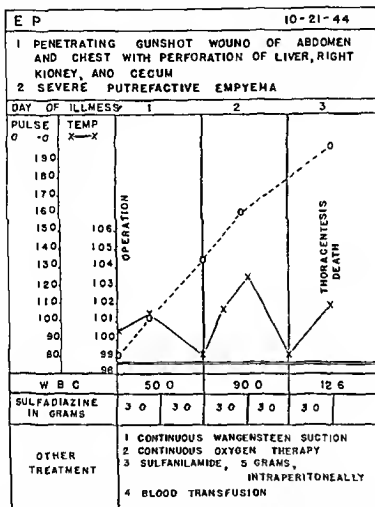


Fig 479—Acute putrefactive empyema with profound toxemia developing in a penetrating thoraco-abdominal wound which resulted in death. In this case the puncture wound of the diaphragm had not been closed, the diagnosis was delayed, and treatment including drainage was started too late.

In the four years prior to that time peritonitis accounted for 31 per cent of the deaths, hemorrhage 24.1 per cent, severe shock 21.3 per cent, and pneumonia 17.2 per cent. Since 1942 the incidence of hemorrhage and pneumonia as causes of death has remained essentially the same, being 30.4 per cent and 17.4 per cent respectively, but that of peritonitis and severe shock has been significantly reduced.

SUMMARY

Although massive hemorrhage from injuries to the major vessels of the abdomen and lower chest, particularly the aorta and vena cava remains a serious cause of death, the mortality rate in penetrating wounds of the abdomen has been significantly reduced for a number of reasons. The early and liberal use of whole blood and blood substitutes has helped to overcome the effects of shock and hemorrhage and has permitted operation under more suitable conditions in a larger number of patients. Laparotomy performed on better risk patients permits more careful and less hurried exploration of the peritoneal cavity with the result that visceral perforations are seldom missed. Damage to the gastrointestinal tract, solid viscera, diaphragm and retroperitoneal structures can be investigated and adequately repaired thereby minimizing peritoneal, pleural and retroperitoneal contamination.

There is evidence that the contamination of the abdominal cavity remaining under these circumstances can be controlled by adequate systemic chemotherapy used in conjunction with early surgery and that sepsis has been greatly minimized as a cause of death.

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THE MANAGEMENT OF MEGACOLON (HIRSCHSPRUNG'S DISEASE)

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MEGACOLON is a rare disorder of the large bowel which has resulted in hypertrophy and dilatation of the affected parts of the colon. Clinically it is characterized by abdominal distention and obstipation. From the therapeutic standpoint it is important to differentiate between the idiopathic variety of megacolon and other similar conditions in which the hypertrophy or dilatation of the colon is secondary to some congenital or acquired obstruction to the fecal stream in the distal portions of the intestinal tract.

The clinical condition of megacolon was first described by Fredrick Ruysch¹ in the seventeenth century and more than a score of authors had recorded similar cases in the scientific literature before Harold Hirschsprung² published his classical account of the syndrome in 1888. He popularized the condition and added considerably to our knowledge of certain types of megacolon so we have come to refer to the congenital or idiopathic variety of megacolon as "Hirschsprung's disease." His original definition was "a condition of congenital high grade dilatation of the colon with thickening of all its tunics especially the tunica muscularis, with retention of large quantities of fecal matter."

The idiopathic form of megacolon is from three to four times more frequently observed in boys than in girls and the congenital origin of the disturbance has been shown by the demonstration of the characteristic changes in the colon of an unborn fetus of seven months gestation.

A few decades ago most of the infants with megacolon died before they reached the age of five years and those children with the less severe varieties of the disturbance rarely reached adult life. Complications such as bronchopneumonia, myocardial failure, volvulus of the colon with perforation of the wall and generalized peritonitis are still the most common causes of death during early life in patients with megacolon. In recent years, however, the important advances which have been made in the supportive treatment by the pediatrician, the improved dietary, medical and surgical therapy and the

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better understanding of the pathologic physiology of the disturbance have all played a part in the improvement of the prognosis of this type of megacolon.

THEORIES ON GENESIS OF MEGACOLON

Defective Muscular Tone of Bowel.—One of the earliest theories relative to the etiology of megacolon was that a segment of the colon was paralyzed or possessed defective muscular tone. Spasm of the anal sphincter muscles with secondary dilatation and hypertrophy of the colon proximal to the rectum was described by Fenwick.³ However, more interest was centered about disturbances of the visceromotor mechanism of the colon and Hurst⁴ suggested that megacolon was due to failure of the sphincter muscles of the anal region to relax when the normal colonic peristalsis reached the rectum.

There are considerable experimental and clinical data to support the theory that megacolon results from this type of failure of coordination which leads to dysfunction of the neuromuscular apparatus of the colon and rectum. In patients with megacolon the affected part is not paralyzed in spite of the fact that it is greatly dilated. Vigorous and even painful peristaltic movements of the colon are regularly observed when the wall of the colon is thickened. When these patients develop intestinal obstruction we find the usual clinical signs and symptoms of mechanical obstruction, yet at operation or at autopsy there may be no demonstrable kinking or twisting of the colon. It is thought that the colon must be contracting against a closed sphincter muscle which fails to relax or it is contracting against some valvular type of obstructing mechanism. Clinicians have reported considerable improvement after manual dilatation of the anal sphincter muscles and after the systematic use of rubber bougies to bring about dilatation of the anal canal and the rectum.

Increased Plastic Tone of Bowel.—Wade and Royals⁵ suggested that megacolon was the result of increased postural or plastic tone of the bowel which is mediated through the action of the sympathetic nervous system just as it is in regard to striated or skeletal muscles. This theory has since been shown to be incorrect, nevertheless it was responsible for opening the vast field of surgery of the sympathetic nervous system in the management of megacolon. Even though their theory of action of the operation is probably incorrect, the end results following properly performed sympathetic denervation of the colon in selected cases of megacolon are surprisingly good and should always receive careful consideration.

Two etiologic hypotheses of megacolon. Firstly, the give rise to loss of tone of the wall of the bowel with secondary distention of the affected portion of the bowel, or, secondly, the diminished tonus of the parasympathetic innervation of the colon and its associated inefficient relaxation of the anal sphincter muscles may disturb the physiologic equilibrium and thus give rise to dilatation of the colon. Overactivity of the sympathetic nerves to the colon is difficult to demonstrate clinically and diminished tonus of the parasympathetic nerves can be demonstrated clinically only by the use of cholinergic drugs.

The lack of coordination between the proximal and distal portions of the colon seems to be the most probable cause of congenital megacolon. In order to understand this mechanism we must familiarize ourselves with the extrinsic as well as the intrinsic innervation of the colon. Peristalsis is a coordinated neuromuscular activity which is dependent upon mechanical and chemical stimuli arising from food being carried along the intestine but acting through the extrinsic nerves and upon the intrinsic nervous plexuses of the bowel. The upper lumbar nerves bring

in the sympathetic impulses while the lower sacral nerves carry the parasympathetic impulses to the distal portion of the colon. The first and second lumbar segments of the spinal cord give exit to those sympathetic nerves which pass through the lumbar sympathetic ganglionated trunks and the lumbar splanchnic nerves into the inferior mesenteric and hypogastric plexuses and then on to the colon. These sympathetic fibers are also intimately associated with the circular muscle fibers of the rectum.

Stimulation of the sympathetic nerves will inhibit colonic peristalsis and tighten the internal sphincter muscle of the anal region. Stimulation of the superior hypogastric plexus (presacral nerve of Latarjet⁴) of sympathetic nerves gives rise to pelvic pain in addition to constriction of the internal sphincter muscle. Stimulation of the parasympathetic fibers from the sacral outflow or irritation of the ganglion of Frankenhauser in the pelvis will greatly increase peristalsis and cause relaxation of the sphincter muscles of the anal region.

PATHOLOGICO PHYSIOLOGIC CONSIDERATIONS

The surgical interruption of the sympathetic nerves to the distal portion of the colon results in a release of rectosigmoidal inhibition and is often followed by evacuation of the lower part of the colon as the sphincter muscles of the anal canal become relaxed. Overdistention of the colon must be combated by all available means for there are many unfavorable effects which may result from prolonged, maximal distention of the bowel. Wangensteen⁵ has described many of these untoward effects in his monograph on intestinal obstructions. He pointed out that the gaseous content of the bowel after obstruction of the sigmoid colon contains only a small amount of oxygen and carbon dioxide and an overwhelming amount of nitrogen. When the intracolonic pressure rises there is a marked diminution in the blood flow to the walls of the bowel. Under such circumstances the colonic pressure may rise from 12 to 52 cm. of water. This, according to Wangensteen, exerts a pressure of 735 cm. of water against each cubic centimeter of surface of the cecum and 340 cm. of water pressure against the wall of the descending colon. This difference in pressure within the colon accounts for the frequency of perforation of the cecum in late or neglected cases of obstruction of the large bowel.

Increased intracolonic pressure also influences the absorption from the bowel. The absorption of dyes or bacteria by the lymphatic vessels is greatly enhanced in all cases of chronic intestinal obstruction and the absorption of materials into the veins or by the peritoneal surfaces is also modified when the bowel is greatly distended. Most of the patients with megacolon who come to operation show enlarged lymph nodes in the mesentery and usually show enlarged lymph channels on the surface of the bowel and in the mesentery. Such lymphangiectasis was considered by Finney⁶ as a cause for megacolon.

Physiologic research directed toward the identification of the chemical substances which the autonomic nervous system utilizes to activate the tissues led to the production of the cholinergic drugs. Loew

showed that the activity of the intestine is increased by its contained choline derivatives. Choline is changed into acetylcholine and acts as a peristaltic hormone which generally increases the intestinal activity. In 1921 Loewi⁹ demonstrated the relationship between acetylcholine and its parasympathetic stimulative action. Dale¹⁰ later showed that acetylcholine is released at all parasympathetic nerve endings on stimulation of these nerves, consequently it serves as a potent chemical mediator in transmitting the excitatory effect from the nerve endings to the reacting cells. The administration of acetylcholine increases the function of the parasympathetic nerves and stimulates peristalsis in the colon.

Klingman¹¹ found that atropine sulfate gave satisfactory response despite the unpleasant toxic effects, so he concluded that the parasympathetic nervous system played an important role in the production of the disturbed neuromuscular function in patients with megacolon.

How a drug which supposedly acts exclusively as a paralyzer of the parasympathetic nerves can actually become effective in establishing better bowel function in megacolon is difficult to explain. Klingman is of the opinion that, with overaction of the parasympathetic nerves, the retention of feces in the colon results from an inability of the longitudinal muscle fibers to expel the feces without help from the circular fibers of the colon. In neurogenic megacolon these circular fibers of the colon are too completely relaxed. In such a case the parasympathetic paralyzant would reduce the inhibitory effect so one should expect some action from the circular muscle fibers.

Still another explanation for the action of a parasympathetic paralyzant was given by Loewi when he showed that a drug like atropine inhibits the action of the parasympathetic nerves not by paralyzing, as had been previously supposed, but by stopping or preventing the action of acetylcholine in or near the reacting cells. He also pointed out that when a complete balance exists between cholinergic and adrenergic substances, atropine acts as a synergist to the adrenergic factor by removing the cholinergic factors. Myerson's experiments support this theory.¹² In particular reference to the gastrointestinal tract, the tonus of the rectosigmoidal apparatus may be diminished by adrenergic action following the administration of a parasympathetic paralyzant.

Another explanation of this action comes from the effect that the parasympathetic paralyzant may have when it acts as an inhibiting factor to the liberation of acetylcholine in the tissues. Aside from being liberated in very small quantities, ordinarily at the termination of the parasympathetic nerves, acetylcholine is also present in small quantities at the termination of the sympathetic fibers at the junction of the preganglionic and postganglionic fibers. A drug which reduces

the liberation of acetylcholine at this junction might sufficiently reduce the overactivity of the sympathetic nerves to bring about a better balance between the two elements of the innervation of the colon.

In some respects the use of a parasympathetic paralyzant is almost paradoxical and one is forced to accept it on the grounds that it is effective in spite of the fact that the mechanism by which it acts is still unexplained. Whatever the explanation might be, clinical experience has demonstrated that the drugs which act exclusively as paralyzing agents to the parasympathetic nerves are beneficial in establishing better emptying of the bowel in certain cases of megacolon.

Atropine should be the drug of choice to inhibit the liberation of acetylcholine but its highly toxic effects contraindicate its regular clinical use. Syntropan (Roche) was found to have an effect similar to atropine on the parasympathetic nerve endings of reacting cells. It controls the tonus of the bowel without interfering with the peristaltic activity. The toxic dose is about twice that of atropine and the administration is not accompanied by the disagreeable effects upon the heart and circulation, the pupils or the glandular secretions. Its effect on the colon is also much greater than that of atropine and it has no atropine-like action on the small intestines. The effective dose of syntropan is also much more readily reached without the appearance of any toxic signs or symptoms.

DIAGNOSIS OF MEGACOLON

The diagnosis of megacolon except in very early infancy is relatively easy and can be made on the basis of the following three cardinal findings: (1) obstinate constipation, (2) marked enlargement of the abdomen and (3) visible peristalsis on inspection of the abdomen.

The clinical history shows that these patients rarely have spontaneous bowel movements and they may even go weeks or months without proper evacuation of the colon. Examination of the stools usually reveals large amounts of indigestible foods which had been ingested weeks before. Some patients develop periods of diarrhea as a result of the irritation from impacted feces in the lower portion of the colon.

The young children with megacolon are usually small and frail and fail to gain weight properly. Their general state of nutrition is poor because of the anorexia and the toxemia which result from the longstanding fecal stasis. The victims of this malady usually show marked muscular weakness and complain of headaches and weakness generally. The skeletal muscles are soft and flabby. There is marked retardation in the development of secondary sexual characteristics in those who reach the age of puberty.

The abdomen may assume tremendous proportions and the enlargement is usually in the portion of the abdomen above the umbilicus.

There is usually marked flaring of the costal margins and the diaphragms may be pushed up into the chest and encroach upon the intrathoracic organs (Fig 480). The skin of the abdomen is usually thin and shiny and on percussion the abdomen is usually tympanitic in spite of the fact that large masses of fecal material can be palpated along the course of the colon (Fig 481). As a rule, there is no free fluid in the peritoneal cavity in the early cases but in the advanced forms of megacolon definite evidence of ascites is usually present. Deep peristaltic waves are often visible over the abdomen and gurgling sounds may be heard either with or without the stethoscope.



Fig 480—Roentgenogram showing severe congenital megacolon. Note flaring of the costal margins and compression of the liver, heart and lungs from the enlarged colon and elevated diaphragms.

Most of the patients with megacolon have an elongated or redundant sigmoid colon and a loop of the sigmoid colon may extend up under the right lobe of the liver (Fig 482). Sudden complications may occur in the form of ulceration of the wall of the colon or perforation of the colon due to volvulus of the long sigmoid loop. Such complications may result in death rapidly unless the complication is promptly recognized and properly treated.

In infants the diagnosis may be extremely difficult. The abdomen is enlarged and visible peristaltic waves over the abdomen may give the clue to the nature of the intestinal disturbance. Diarrhea may alternate with constipation or the diarrhea may predominate for the



Fig 481—Roentgenogram of young girl with megacolon involving descending colon and sigmoid. Note ascending and transverse colon are about normal size. Large masses of fecal material and barium in the distal part of the colon.



Fig 482—Barium enema showing elongated and enlarged sigmoid colon which extends along the right side of the abdomen and pushes the liver upward and outward.

first few weeks of life Persistent vomiting during the first few weeks of life is not uncommon When an infant presents these signs and symptoms one should suspect congenital megacolon but careful differential diagnosis must be made to rule out congenital duodenal obstruction, celiac disease, tuberculous peritonitis and rickets Mechanical obstruction in the rectum must be ruled out by digital or proctoscopic examination If the child's condition will permit, the colon should be thoroughly cleansed and a thin suspension of barium should be instilled slowly through the rectal tube so the size and shape of the lower portion of the colon can be determined accurately on the



Fig 483—Roentgenogram showing barium mixed with fecal matter three weeks after small amount of barium was given by mouth

roentgenograms Contrast enemas using a small amount of air in the colon frequently help in the roentgenologic interpretations If the colon is very large it is very important to evacuate all of the barium from the colon by mechanical or medicinal means, otherwise serious fecal impaction may result

In older children and in adults the palpation of the abdomen gives the impression of a doughy consistency of the intra abdominal contents and frequently masses of varying sizes can be seen and felt along the course of the descending colon and the sigmoid colon (Fig 483) The masses may vary in consistency from that of thick dough to that of hard putty These masses are readily recognizable as fecal

iths since pressure over the mass with the finger usually leaves an indentation in the mass. The masses may be found in any part of the abdomen.

It must be remembered that congenital megacolon may exist in the adult patient and remain as a latent or asymptomatic disturbance for many years (Fig. 484). In such patients the muscular dysfunction is compensated for and spontaneous bowel movements are frequently possible. These patients rely mostly on enemas of various types for regular evacuation of the lower portion of the colon. In spite of the



Fig. 484—Roentgenogram showing the latent or asymptomatic megacolon with primary involvement of the sigmoid colon in an adult.

apparent satisfactory functioning of the colon the anatomic or pathologic changes may be very extensive and the serious complications of volvulus, perforation, peritonitis or massive fecal impaction may take place at any time.

PATHOLOGICAL CHANGES IN MEGACOLON

Analysis of the gross pathological changes in the colon of patients with congenital megacolon reveals that about 33 per cent of them have involvement of the sigmoid colon alone. Bartle¹³ is of the opinion that the sigmoid colon is invariably involved but always in conjunction with other adjacent portions of the large bowel. Analysis of the cases which have been observed at the Mayo Clinic shows that 42.3

per cent had involvement of the rectum and 11.5 per cent had involvement of the cecum. The parts of the colon proximal to the hepatic flexure were involved in 26.9 per cent of their cases. In all of our cases of congenital megacolon there was involvement of the sigmoid colon and the portions of the large bowel immediately adjacent and proximal to the sigmoid colon.

In the congenital variety of megacolon the wall of the affected portions of the colon is greatly thickened and presents the physical characteristics of thick, wet leather (Fig. 491). The blood vessels on the surface are enlarged and the lumen of the bowel is usually ten to twenty times enlarged. The taenia and the haustra are absent and the epiploic appendices and the mesentery are thickened and elongated. Many large lymph nodes are embedded in the thickened mesentery. The sigmoid colon is usually elongated and because of its elongated mesentery it may present several extra loops. This is of particular importance because it predisposes to volvulus and secondary perforation of the colon.

Adamson and Aird¹⁴ found that the nerves of the colon were enlarged but this increase in size was due to fibrous tissue rather than to any numerical increase in nerve fibers. The increase in the size of the nerves is only part of the general increase in connective tissue throughout the mesocolon.

The involved parts of the colon show signs of chronic inflammatory changes such as hypertrophy, fissures, ulcerations and even an ulcerative type of colitis with perforation of the colonic wall. Chronic lymphatic stasis was usually present with some cystic degeneration in the lymph nodes. The ganglion cells and fibers in the plexuses of Auerbach have been found to be smaller and many of the ganglia were imperfectly formed.

THE TREATMENT OF MEGACOLON

GENERAL MEASURES

After the diagnosis of megacolon has been established the patient should be hospitalized for further evaluation and study of the type of abnormal function of the bowel. When these patients are brought into the hospital the distal part of the colon is usually packed with feces and often large fecal concretions are found which cause subacute colonic obstruction with marked gaseous distention of the entire colon.

This fecal matter must be carefully removed by using repeated cleansing enemas of warm, soapy water together with the oral administration of mineral oil and if necessary the instillation of mineral oil into the colon by means of a rectal tube.

As the first step in the management of megacolon a careful rectal

examination with the gloved finger must be done to make certain that there are no congenital strictures in the rectum. If however such strictures are present they must be treated by regular dilatation with the finger or with soft rubber bougies before any other form of treatment is instituted. These strictures are usually situated 1 or 2 cm from the anus so the child's mother or the nurse can be taught to carry out the manual dilatation regularly. Occasionally these strictures are firm and unyielding and must be treated surgically in order to overcome the obstruction.

Rectal dilatation has been systematically employed by Hurst who advises the use of soft rubber bougies of increasing size to induce better relaxation of the internal sphincter muscles. Such mechanical dilatation of the anal canal and the rectum may be of real value and should always be part of a well planned medical regimen. Adolescent children and young adults have reported many weeks of relief following a single manual dilatation of the sphincter muscles and evacuation of the contents of the lower portion of the colon. Such forceful dilatation of the rectum should always be carried out under general or spinal anesthesia. Overstretching of the sphincter muscles usually leads to a short period of fecal incontinence.

A great variety of medical and surgical methods of treatment have been advocated in the management of congenital megacolon. It is our firm belief that every patient with megacolon must first be carefully studied by the pediatrician or by the internist and all available conservative methods of management should be given a fair trial before any surgical intervention is contemplated. It is a well established fact that children under four years of age do not tolerate surgical operations well and we believe they should not be exposed to the hazards of extensive surgical operations unless perforation of the colon or volvulus makes such an operation imperative.

It is sometimes extremely difficult to decide whether conservative management should be continued or whether some surgical procedure should be advocated. The age of the patient and the extent of the involvement of the colon usually serve as valuable guides for therapy since young children should always have the benefit of prolonged medical treatment and those children over five years of age with extensive involvement of the colon should have the benefit of properly planned and executed surgical treatment. The sudden development of some serious complication like intestinal obstruction, volvulus or perforation makes surgical intervention necessary regardless of the general condition of the patient. The surgeon must then rely upon supportive measures to help tide the patient over the critical phase after operation.

Obviously there are many children who are suffering from chronic constipation and present roentgenologic evidence of some anatomic

anomaly of the colon such as an undescended cecum, a mobile cecum or a redundant loop of the sigmoid colon. Our experience has proved that this type of condition can usually be adequately cared for by special training and conservative measures alone.

MEDICAL MEASURES

As a remedial agent the use of acetylcholine is limited because it is rapidly hydrolyzed to less active substances by certain esterases in the blood stream. Oral administration of this drug is not effective and the results from the parenteral administration are inconstant unless the dosage is so large that the peristaltic action is overshadowed by the undesirable toxic manifestations of the drug. Although it is physiologically potent, its instability and its frequent alarming toxic effects after parenteral use have discouraged its use in the medical management of megacolon.

In the early part of 1935 the chemical compound of *acetyl-beta-methylcholine* (methylol and methylol) became available and the problem of the medical management of megacolon began to change. This chemical substance was synthesized by Major and Cline¹⁵ and chemically it is a derivative of acetylcholine. It has the advantageous pharmacological properties of acetylcholine but it is much more stable in the tissues. When given orally it produces definite and continuous stimulation of the parasympathetic nerves usually without untoward toxic manifestations. It slows the heart action, lowers the systemic blood pressure, dilates the peripheral blood vessels, stimulates the sweat glands to greater activity, increases the tone of the intestines and stimulates peristalsis. It may constrict the bronchioles and incite an asthmatic attack and in large doses it may produce abdominal pain and vomiting. The ill effects of this drug can be abolished immediately by the subcutaneous injection of as little as $\frac{1}{400}$ grain of atropine sulfate.

Experience has shown that the optimum times for the administration of acetyl-beta-methylcholine bromide are (1) thirty to sixty minutes after breakfast, (2) in the midafternoon, or (3) at any juncture to parallel and enhance an observed daily intestinal rhythm.¹⁶ If the drug is given before breakfast we have found that the patients usually develop the toxic manifestations of nausea, vomiting and abdominal pain. This drug should be administered for a period of from five to ten days if we expect the autonomic imbalance to be corrected with the establishment of the new reflexes which are necessary to regulate intestinal function.

An average initial dose of acetyl-beta-methylcholine bromide for patients with megacolon is 0.1 gm, increased if necessary to 0.2 gm within two or three days. Then after several more days with this daily dose if the bowel function is still not well established an additional

dose of 0.1 or 0.2 gm in midafternoon may be prescribed. As the drug becomes effective in bringing about more normal function of the bowel the daily enemas are discontinued but the oral administration of the mineral oil is continued because of its lubricating action in the colon.

In some patients 0.2 gm given each morning and in midafternoon is required to initiate bowel movements. If this quantity of the drug produces diarrhea the dose should be reduced to 0.1 gm the next time the drug is given. When the patient becomes stabilized on a dose of the drug which produces one or two stools daily we usually release him from the hospital with instructions to take 0.2 gm of acetyl betamethylcholine bromide each morning about thirty minutes after breakfast and 1 or 2 tablespoonfuls of mineral oil each evening and report back to the doctor in two weeks. An occasional enema should be used if the patient becomes constipated or is troubled with gaseous distention of the colon.

Prostigmine bromide has been used as an augmentor of the acetyl betamethylcholine bromide. Prostigmine prevents the destruction of acetylcholine by the esterases in the blood. In moderate doses prostigmine bromide is a safe drug to use and it does not disturb the blood pressure or the heart action.

Klingman¹¹ expressed the opinion that *syntropan* (Roche) is of value in the management of certain cases of megacolon because it is a parasympathetic paralyzant and has an action similar to atropine in inhibiting the liberation of acetylcholine. He reported satisfactory clinical improvement following the use of syntropan on five patients with megacolon. Klingman¹¹ and Law¹⁶ are not entirely in agreement concerning the basis for drug therapy in patients with megacolon since some of the benefits which Law ascribes to the use of drugs might also be explained on the basis of the excellent supplementary medical treatment which his patients received in conjunction with the drug therapy.

We are convinced that the medical management of megacolon must be employed vigorously to minimize the distention of the colon and prevent nutritional changes in children at least up to the age of five years. We also believe that medical management should be continued after that age especially when the child continues to grow normally and continues to have satisfactory evacuations of the bowel. Medical management must always receive its proper attention as an active pre-operative measure as soon as it is recognized that the disturbance of colonic function cannot be completely controlled by the general and medical measures alone. Unfortunately the surgeon frequently loses sight of this important fact and the patients come to operation improperly prepared for such an extensive surgical procedure.

SURGICAL MEASURES

The surgical measures which are of value in the management of megacolon can be divided roughly into the *emergency procedures* and the *elective procedures*. The emergency procedures are to be used only as an heroic attempt to save a life after some acute surgical catastrophe such as volvulus, complete intestinal obstruction, gangrene of the obstructed loop of bowel or peritonitis from perforation of the colon has taken place. The minimal amount of surgical manipulation necessary to accomplish the immediate task is all that should be done in those patients with megacolon who may require immediate or emergency surgical intervention.

At the top of the list of elective procedures we have the various kinds of sympathectomy. When medical treatment and sympathectomy both fail to bring about relief in patients with megacolon then we must consider the other elective procedures, such as partial or segmental colectomy or even total colectomy. When patients are being prepared for colectomy the elective operations of cecostomy and transverse colostomy should be considered to permit better cleansing of the rest of the colon and for the safer execution of obstructive resection of the colon during and after partial colectomy.

Sympathetic Denervation of Colon.—Before the advent of sympathectomy in the management of megacolon there was only a slight difference between the mortality rates following medical and surgical measures. Passler¹⁷ reviewed the literature and collected 117 cases of megacolon which had been subjected to sympathectomy. Complete relief was reported in thirty-eight of the cases and improvement was observed in sixty-four cases. There was failure to obtain benefit in twelve patients and three died. In our own series of nineteen patients with congenital megacolon showing an age distribution of two months to twenty years, we have subjected fourteen to the operation of sympathetic denervation of the colon. Only one of these patients failed to obtain satisfactory function of the bowel following the sympathectomy and many months of intensive medical management. This patient will be reported upon more in detail in the paragraphs devoted to colectomy.

The operation of sympathectomy is an empirical method of treatment. There are various minor differences in the operations which have been described yet all of them are directed toward the interruption of the sympathetic nerves to the affected portion of the colon. It must be emphasized that patients who have been subjected to sympathectomy must be observed carefully for a long time after the operation because it is not uncommon to have fecal impaction or even volvulus take place many weeks after the operation.

Sympathectomy will not produce satisfactory results in cases in which the muscle power of the colon has been lost. We have observed

that there is a gradual diminution in the size of the colon as measured by roentgenologic studies for several years following the sympathectomy. We have no new information about the changes which take place in the thick, heavy wall of the involved portion of the colon after sympathectomy, for none of our patients have had to be reoperated upon and none has come to autopsy. One young man whom we have followed for nearly fourteen years after sympathectomy still shows some thickening of the colon but he has continued to have normal function of the colon despite the fact that he had never had a spontaneous bowel movement during the first nineteen years of his life prior to the sympathectomy.



Fig. 485—Roentgenogram showing marked dilatation of the transverse colon in a man 53 years of age. The wall of the colon was thin and atonic.

White and Smithwick¹⁸ mention some important observations which throw additional light on the effect of sympathectomy upon the *normal* colon. They determined the intracolonic pressure relationship before and after bilateral lumbar ganglionectomy, and combined ganglionectomy and splanchnicectomy which were performed for the cure of Raynaud's syndrome and malignant hypertension. They were unable to show any alterations in the basic tone of the bowel, the peristaltic activity, or the *sensory acuity* of the bowel following such complete sympathectomies. These observations however have never been made on patients with congenital megacolon.

Wade¹⁹ observed that patients who showed hypertrophy of the

colon and visible peristalsis did well following sympathectomy. When hypertrophy of the colon was absent, the improvement which followed the sympathectomy was minimal and in those patients in whom the disturbance of the colon had progressed to the stage of marked dilatation with thin, weak musculature of the colon, the results following sympathectomy were completely unsatisfactory. These patients were in constant danger of great gaseous distention of the bowel and kinking of the sigmoid loop. They required regular enemas to bring about evacuation of the bowel. One such patient came under our observation and because the bowel was greatly distended and thin

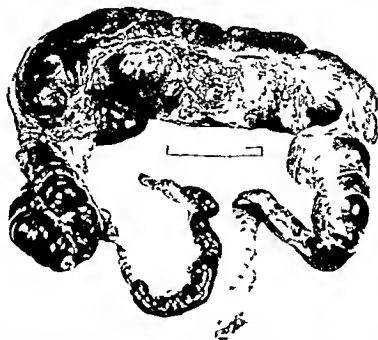


Fig 486—Photograph of entire colon and terminal ileum removed at autopsy from a patient with enormous dilatation of the right half of the colon and secondary volvulus with gangrene of ascending colon. The rule in the center is 6 inches long.

walled we were certain that sympathectomy would give no improvement (Fig 485). Arrangements were made for him to enter the hospital and be prepared for the resection of the colon and an ileorectostomy. Without our knowledge and while he was at home he developed acute intestinal obstruction from volvulus of the ascending colon with gangrene of the cecum. When he was brought to the hospital he was moribund and autopsy showed the tremendous dilatation of the entire right two thirds of the colon with volvulus involving the ascending colon and cecum with gangrene of the bowel. The photograph shows the specimen after it had been untwisted (Fig 486).

Technical Considerations—The operation of lumbar sympathectomy was first performed in the treatment of megacolon by Wade and Royal¹ in 1927. Their operation consisted of ramisection of the left lumbar sympathetic ganglia. Since that time several modifications of their original operation have been described in the medical literature. Rankin and Learmonth²⁰ advocated the resection of the superior hypo-



Fig. 487—Drawing showing anatomic relation of various portions of the abdominal sympathetic nervous system.

gastric plexus (presacral nerve of Latarjet) together with the removal of the inferior mesenteric plexus of sympathetic nerves (Fig. 487). Judd and Adson²¹ reported good results in the treatment of megacolon from bilateral lumbar sympathetic ganglionectomy. More recently however they suggested the resection of the lumbar splanchnic nerves together with the upper lumbar sympathetic ganglia for the more severe varieties of megacolon.

All of the operations upon the lumbar sympathetic nerves also interrupt important sympathetic fibers to other organs beside the distal portion of the colon. Resection of the superior hypogastric plexus interrupts the motor fibers to the seminal vesicles and the prostate gland and abolishes the ejaculation of semen which produces sterility in the male. When the second and third lumbar sympathetic ganglia are removed the power of ejaculation of semen is not disturbed but vasomotor paralysis of both lower extremities takes place so the skin of the legs and feet becomes hot and dry. This vasomotor paralysis in the extremities causes no discomfort or disadvantages.

Telford and Stopford² have suggested the resection of the pre-aortic plexus of sympathetic nerves in order to avoid sterility in the male and at the same time not interfere with the vasomotor control of the lower extremities. This at first appeared to be the operation of choice but because of the uncertainty of the anatomical distribution of these sympathetic fibers these authors finally decided that bilateral lumbar sympathetic ganglionectomy would give more uniform denervation of the colon in patients with megacolon.

Scott and Morton³ made an important contribution to this field when they suggested the use of spinal anesthesia as a means of inhibiting the sympathetic impulses to the colon to bring about evacuation of the colon in patients with megacolon. This test aids in the selection of suitable cases for sympathectomy.

After the muscle tone of the colon has once been lost through overdistention from feces or gas, the operation of sympathetic denervation of the part will not give satisfactory results. It is important, therefore, to prevent such overdistention of the colon in order to preserve the tone of the bowel in all patients with megacolon who might subsequently be treated by sympathectomy.

We believe that the operation of abdominal sympathectomy should be performed by the *transperitoneal* route since that approach also affords an excellent opportunity for the surgeon to examine the entire colon and to determine accurately the extent of the pathological changes in its wall. By this route both lumbar sympathetic trunks and their ganglia can be removed at the same operation. Other important sympathetic nerves which course along the pre-aortic area and into the inferior mesenteric plexus can also be interrupted at this operation if the severity of the megacolon demands such an extensive interference with the sympathetic innervation of the colon.

The *retroperitoneal* approach to the lumbar sympathetic ganglia and trunks possesses no real advantage in the management of megacolon and has the great disadvantages that two separate operations are necessary to completely denervate the colon and the surgeon never gets a chance to determine the extent of the pathological changes by direct examination of the bowel.

surgical removal of the obstructing lesion still fails to bring benefit to the thin walled and overdistended colon, should be given relief by colectomy. Volvulus with gangrene of the enlarged and dilated colon frequently presents itself as a serious complication in this type of megacolon (Fig 486).

In addition to these three groups we believe that subtotal colectomy should be carried out in those patients with megacolon who show no contraction of the bowel or evacuation of feces following spinal anesthesia and for whom intensive drug therapy fails to reduce the size of the involved colon or reestablishes the peristaltic activity.

Subtotal colectomy is not indicated in infants with megacolon unless they present complications which make resection of part of the colon necessary to remove gangrenous areas. Even under such circumstances it is much safer to exteriorize the damaged portion of the colon and then perform the resection of the colon in stages at some later date.

In a review of the literature Carey was able to study ninety-five cases in which subtotal colectomy was performed for megacolon. The mortality rate for these cases was 27 per cent.

Dixon²⁶ reported that, in his experience, in patients who have had great dilatation of the colon for many years there are always permanent changes in the wall of the bowel and subtotal colectomy is the only surgical procedure which will give satisfactory improvement.

Barrington Ward²⁷ reported five cases in which total colectomy was done and an ileocolostomy or ileorectostomy was performed to reestablish the continuity of the bowel. In the 102 cases of megacolon treated by partial colectomy and reported by Ask-Upmark²⁸ the benefits were observed immediately and the author thought they would be permanent.

The one patient in our series, a girl 20 years of age, who failed to show improvement after intensive medical treatment and sympathectomy was subjected to resection of the sigmoid colon (Fig 489). After the sigmoid colon was removed from the rectum by the use of Payr clamps in an aseptic manner, the distal end of the sigmoid colon was freed by dividing the mesentery so the enormously dilated and hypertrophied bowel could be emptied of the fecal content by placing the distal end over the side of the operating table and removing the Payr clamp. This was excluded from the field of operation and the entire contents of the colon were milked out. The fecal matter had the consistency of putty and in all 42 pounds of feces and colon were removed without causing any untoward reaction in the patient during the entire operation. A Devine type of colostomy was made so that the distal end of the descending colon and the upper end of the rectum could be brought together in such a way that the fecal stream will later be reestablished by crushing the spur between the two

portions of the bowel (Fig. 490). We prefer to allow several months to elapse before the continuity of the colon is reestablished in order

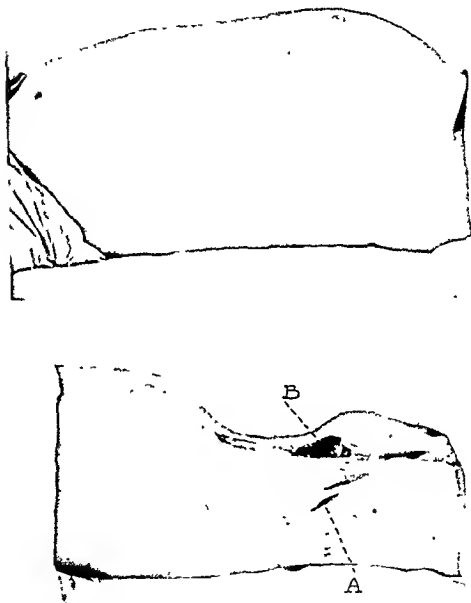


Fig 489—Photographs of a young woman with congenital megacolon. Pictures taken before and ten days after partial colectomy (see Fig. 490). A, Site of cecostomy. B, Site of Devine colostomy.

to give adequate time for the medical and drug therapy to completely restore the function of the remaining portion of the colon. At this

time, two months after operation, the colon is functioning normally and the portion visible at the colostomy opening is of normal size and activity. The patient has gained 21 pounds in weight and is normally active.

The removal of a greatly dilated and thickened portion of the colon (Fig 491) is a somewhat different surgical procedure from the resection of a diseased portion of an otherwise normal colon. It is our opinion that all of the involved colon should be resected by a one stage aseptic procedure and when possible a temporary double-barrel

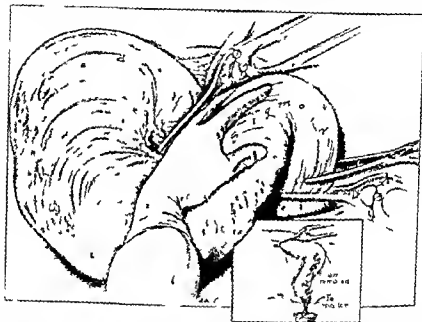


Fig 490—Drawing showing the resection of the enlarged sigmoid colon. Note method of emptying entire large bowel of large quantities of putty like fecal material without contamination of the field of operation. Wounds healed promptly without infection.

colostomy should be constructed. This colostomy can be closed any time from a few weeks to several months but not until the patient has shown definite general improvement. If the caliber of the entire colon is greatly increased it is wisest to remove it entirely or at least to the upper part of the rectum. The proximal end of the rectum and the distal end of the terminal portion of the ileum are brought to the outside of the abdomen and the final anastomosis should be made as a second stage procedure at some later date. The procedure described above gives us hope of saving portions of the colon which may be showing only secondary changes that may be reversible. Certainly with the modern drug therapy it should be possible to restore normal

unction to parts of the colon which previously were thought to be involved in the process of megacolon

It has been found that a liberal left rectus incision is a satisfactory type of abdominal opening to have for it affords adequate exposure of the splenic flexure of the colon which occasionally is very difficult to mobilize adequately. The mesentery of the sigmoid colon and the descending colon is usually elongated and this adds greatly to the ease with which an enlarged colon can be mobilized and even brought out onto the abdomen to facilitate the resection. The anal sphincter



Fig 491—Photograph of the portion of the sigmoid colon removed at operation. Note the leather like thickened wall and the dilated blood vessels on the surface.

muscles should be forcefully dilated at the completion of the colectomy and again when the colostomy is closed.

Because of the poor healing qualities of the enlarged bowel due to long standing distention and lymphatic stasis in the tissues, the single stage resection of a part of the colon in megacolon and an immediate anastomosis between the proximal and distal segments of the bowel is fraught with danger of serious complications. We do not recommend this one stage procedure in the management of the more advanced types of megacolon.

In the interval between the resection of the portion of the colon and the closure of the colostomy and after the immediate postoperative period, the patients are allowed a high protein, high vitamin and low residue diet. They may wear a colostomy bag or simply take a cleansing enema through the proximal loop of the colostomy each morning and then just wear a pad of soft material over the colostomy opening. They are taught to carry out irrigations of the lower loop of the colostomy at regular intervals.

SUMMARY

Because of the incomplete and sometimes apparently conflicting evidence we are not justified in making any exact statements concerning the pathologico physiologic mechanisms which are at work in the production of congenital megacolon. Experimental evidence, the effect of surgical interruption of the sympathetic nerves to the colon and the action of cholinergic drugs certainly tend to support the neurogenic theory of megacolon as a functional imbalance of the autonomic nervous system which innervates the colon. Since there is no exact test for overactivity of the sympathetic elements of the autonomic nervous system, the final decision about when to do a sympathectomy to reduce the hyperactivity of the sympathetic nerves must be empirical. Sympathectomy should not be done in the very young children and the results in patients with great dilatation of the colon and weak musculature are very discouraging. Sympathectomy does not miraculously restore function of the bowel in all patients with megacolon and adequate parasympathetic tone and strong colonic musculature are absolutely necessary for normal peristalsis and evacuation of the bowel. Patients with vigorous visible peristalsis and hypertrophy of the wall of the colon usually respond best to the operation of sympathectomy.

The administration of some cholinergic drug which should be the remedial agent for diminished tone of the parasympathetic nerves is the only known functional test for tonus of the bowel, but its use is also empirical. The proper and prolonged use of acetylbetamethylcholine bromide has proved valuable in the management of megacolon and might be a valuable adjuvant in the management of those patients with megacolon who have not received complete or lasting relief from sympathectomy.

When the operation of sympathectomy is performed it is important to remove sufficient fibers from the sympathetic nervous system to produce complete denervation of the involved portion of the colon.

In advanced types of megacolon and in certain types of acquired dilatation of the colon it may be expedient to remove the involved portion of the colon and later restore the continuity of the bowel. This operation of colectomy is especially valuable in the management

of those types of megacolon which have failed to respond to intensive medical and drug therapy or sympathectomy.

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TECHNIC OF ANASTOMOSIS OF THE COLON FOLLOWING RESECTION

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IN the surgical removal of cancer of the colon there is common agreement among surgeons as to the fundamental objectives desired. Attempt is always made to transect bowel at points wide of the primary growth, to remove an extensive area of the regional mesentery and its contained lymphatic structures, and to preserve blood supply to the remaining segments of colon. Beyond these points of agreement there are differences in practice both in the technics using during the resection and in methods used for restoring the continuity of bowel.

At the time of operation the surgeon may elect to reestablish continuity of the intestine immediately or he may choose a method requiring delayed anastomosis, such as a modification of the so called Mikulicz procedure or obstructive resection. At the Cincinnati General Hospital it has been the practice to follow resection with immediate anastomosis, by either an open or closed method, in all except occasional cases¹. In order to do this it is necessary to establish suitable conditions for the avoidance of sepsis and for primary healing by use of careful preoperative, operative and postoperative measures. Suitable conditions will be defined in terms of clinical criteria throughout this paper. If these conditions cannot be met with respect to the individual case, it is safer to resort to exteriorization and delayed anastomosis. If they can be realized, primary anastomosis becomes a safe method and usually permits a wider resection of the mesentery. Also it shortens the period of hospitalization for patients and obviates the necessity for secondary operative procedures. The latter two considerations are largely economic and they are of importance only if safety is established.

CONSIDERATIONS IN THE PREPARATION OF THE PATIENT FOR RESECTION

Once the diagnosis of carcinoma of the colon is made and the lesion is localized by sigmoidoscopy or roentgenology, the presence of constipation or obstipation, abdominal distention and x ray evidence of retention of gas, fecal material or barium indicate obstruction. In this

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clinic any degree of chronic or acute obstruction due to lesions distal to the hepatic flexure is relieved by antecedent proximal colostomy. Neither distended thin nor edematous thickened intestinal wall lends itself to safe anastomosis. Of equal importance is the fact that systemic disturbances secondary to obstruction militate against recovery. These may be disturbances in chemistry, nutrition and water balance and in mechanical interference with the respiration due to abdominal distention. Tangential cecostomy is preferred in cases of simple obstruction because it provides adequate decompression, it is safely and easily performed under local anesthesia in one stage and in most instances closes spontaneously. If operative closure is required it is a relatively simple procedure. If associated local inflammation is present complete diversion of the fecal content as well as decompression is essential. Fever, leukocytosis, tenderness, palpable fixation and fistulous tract formation are signs of inflammation. When these are present in connection with lesions at or distal to the splenic flexure a modification of the Devine colostomy performed on the right or left half of the transverse colon is used. The technic for this and the method for later closure are as described by Ochsner, DeBakey and Rothschild.

Obstruction secondary to lesions in the cecum and ascending colon is encountered rarely. This is due to the fungating quality of the growths with less tendency to scirrhous contracture, the larger lumen of the bowel and the fluid consistency of its contents. If obstruction is present here it often denotes incurability by resection either because of local extension of the tumor or of widespread metastases. Signs of associated local inflammation are also frequently present. Often the relief of obstruction in the right colon may be accomplished by use of the Miller-Abbott tube or continuous gastric suction and frequent small enemas. Unless distinct progress is made in two or three days decompression is then best obtained by performing an ileotransverse colostomy through a short transverse incision. In our hands simple anti-peristaltic side-to-side anastomosis has often proved valuable. If the general condition of the patient and local condition of the bowel justify the procedure the ileum may be divided and the end turned in before the anastomosis is made.

In the absence of obstruction we do not hesitate to perform resection with immediate anastomosis without decompression. The preoperative management of these cases and of those in which obstruction has been relieved are about the same. In the supportive management anemia is treated by adequate transfusion of whole blood and a diet high in carbohydrates, protein and calories and low in residue is given. If the oral intake is not adequate solutions of amino acids, glucose and saline are used intravenously. Daily minimum requirements of vitamin B are satisfied.

In addition to the supportive management every attempt is made to cleanse the bowel as thoroughly as possible. Collections of gas, stool and barium at the time of resection interfere with exactness in technic and increase opportunities for soiling of the peritoneum. A cleansing enema of saline or tap water is given by rectum and through the colostomy each day. Succinylsulfathiazole is given orally each six hours for five days before operation. The dosage is calculated at the rate of 0.25 gm. per kilogram of body weight for twenty four hours. On the day before operation an x ray examination is made for the presence of gas, stool and barium in the colon. At this time the patient is placed on a liquid diet, and continuous gastric suction is begun on the evening before or the morning of operation.

On the day of operation the skin is shaved widely and prepared by gentle washing for five minutes with gauze saturated in 1:100 aqueous solution of cetylpyridinium chloride (ceepryn chloride). Towels and drapes are applied with regard to the planned location of the incision. All lesions of the colon except those lying very low in the sigmoid are approached through a transverse incision, often extending into the flank as described by Harg³. We are convinced that the transverse incision affords better exposure than a vertical one, less retraction is required, wound disruption is encountered less often, there is less postoperative pain and splinting of respiration, and healing occurs with a finer scar. The wound is isolated from the skin by fixing the under sides of towels to skin edges with Michel clips. Careful attention is paid to hemostasis and the subcutaneous and muscular layers are protected from trauma and from the field of resection with moist laparotomy packs.

PROCEDURE FOR LESIONS IN THE CECUM, ASCENDING COLON AND HEPATIC FLEXURE

Upon opening the peritoneum first the liver and then the regional lymphatic area are palpated for metastases. (If remote metastases are present palliative resection may be done. Many of these patients remain in relative comfort for months.) The primary growth is examined with care, since rough handling may result in perforation and soiling. If there is evidence of an active inflammatory process extending beyond the bowel wall, with or without abscess, ileocolostomy is done without resection.

If this complication is not present, the cecum, ascending colon and hepatic flexure are mobilized by incising the avascular lateral mesenteric reflection. The bowel is rotated mesially and the ureter and spermatic or ovarian vessels are identified from their origin down to the brim of the pelvis and spared. The retroperitoneal fat and lymphatic bearing tissue are removed using a gentle wiping process with gauze alternating with sharp dissection, and carried mesially with

the bowel and its mesentery to the points of origin of the right colic and ileocecal arteries. At the upper end of the field the descending portion of the duodenum is identified and the beginning of the transverse mesocolic reflection is divided at its attachment to the duodenum and to the anterior surface of the head of the pancreas. The dissection below is carried proximal to the cecum to include the mesentery of about 12 cm. of the terminal ileum incising only the serosa. The entire mobilized segment is then elevated and its blood supply visualized. The points for division of the transverse colon above and the ileum below are selected and the mesial reflection of mesentery is incised with a scalpel from these points to an apex at the points of origin of the right colic and ileocecal arteries. The vessels are isolated, divided between clamps and transfixed with No. 000 silk. At the points selected for division of the transverse colon and the ileum the serosa is carefully cleansed of fat and mesenteric tissue by a gentle wiping process with a single layer of gauze over the finger. Small perforating vessels are clamped as they are encountered close to the serosa, divided with a scalpel and ligated with fine No. 0000 silk. This is done for a sufficient distance to permit the placing of clamps and for an additional margin of serosa to allow later inversion or anastomosis without interposition of fat, long segments of vessels or large ligatures. Pairs of Kocher clamps are applied in a position to shorten the antimesenteric borders of the viable segments. The bowel is then divided with cautery at each site and the specimen is removed.

At this point either a side to side anastomosis similar to the method of the Halsted entero-enterostomy⁴ or an end to side anastomosis somewhat according to the technic described by Rankin is employed. If the side to side method is used, simple closure of the ends of the ileum and transverse colon is made over the clamps with a single row of Halsted mattress sutures of No. 000 silk. These are laid in place to include the submucosa, drawn up to accomplish inversion as the clamp is withdrawn and tied. The closure is then reinforced by placing a Lembert mattress suture between each two Halsted mattress sutures using No. 0000 silk. Another method often used is that of an inverting right angle (Cushing) suture of No. 0 chromic catgut over the Kocher clamp. This suture, after the clamp is removed and inversion is complete, is continued back as a second row and tied. We prefer either of these methods to that of ligating the bowel and inverting the ligated stump because they avoid cavities closed at each end with ligatures.

After both ends of the bowel are closed, the terminal ileum is held parallel to the longitudinal band of the transverse colon and the side-to-side anastomosis is done near the ends in order to leave as little blind stump as possible. The field is carefully walled off with gauze packs. Traction sutures of silk are placed at each end of the proposed

anastomosis, and a posterior continuous suture of No. 000 silk is placed (Fig. 492, 1). Halsted mattress sutures of No. 000 silk are then laid anteriorly (Fig. 492, 2). These are next pulled aside, half to each end (Fig. 492, 3). Before opening the bowel a temporary occlusion is produced to prevent gross soiling. Rubber-shod clamps, or soft lead bars (5 by 3 mm. in cross section and covered with soft rubber tubing)

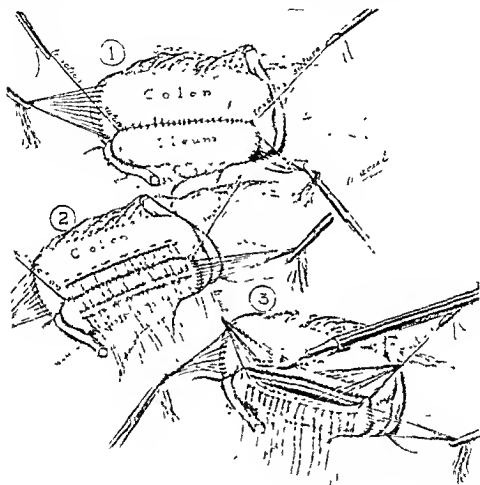


Fig. 492—Steps in side-to-side ileocolostomy. 1. Posterior continuous sutures of silk between two traction sutures. 2. Anterior row of Halsted mattress sutures placed. 3. Mattress sutures pulled aside; incisions made in bowel and vessels clamped and tied with catgut or coagulated.

bent like a hairpin can be placed across the bowel. One is used across the ileum and one across the colon. At the site of the anastomosis itself no clamps are used. The bowel is held up by the assistant lifting the traction sutures, and there is ordinarily no escape of intestinal contents. The bowel is opened with a knife and scissors or with high frequency cautery, and bleeding points are clamped and

tied with No. 000 chromic catgut or they are coagulated (Fig. 492, 3). The posterior suture line is reinforced with a continuous lock stitch of No. 0 or 00 chromic catgut which goes through the entire thickness of both walls (Fig. 493, 4). The ends of the anterior row of mattress sutures are pulled up, the traction sutures are cut or pulled aside and when the mattress sutures are drawn up to approximate the bowel and tied the anterior lip of the anastomosis is closed (Fig. 493, 5). A Lembert suture of No. 0000 silk is placed between each two mattress sutures. The angles of the anastomosis are reinforced with mattress sutures of No. 000 silk and the occluding rubber shod clamps or lead bar clips are removed. After removal of the protecting gauze

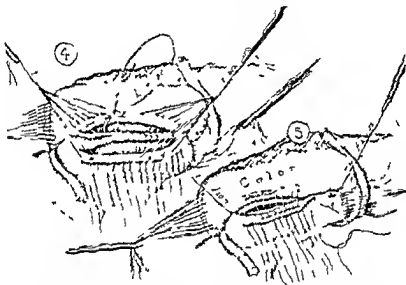


Fig. 493—Steps in side to side ileocolostomy (continued) 4 Posterior lock stitch of catgut through all layers of bowel 5 Mattress sutures pulled up and tied

packs the gloves are changed before continuing the operation. The overlapping folds of the mesentery are sutured together to close the defect, care being taken not to injure the blood supply. We have abandoned the use of a sulfonamide in the peritoneal cavity, relying upon systemic administration by the intravenous or subcutaneous routes only in occasional cases where soiling has occurred.

If the end to side method of ileocolostomy is used the cut end of only the colon is closed and a site is selected for the anastomosis. A portion is tented up by grasping it with two Allis clamps. A Kocher clamp is placed across this area longitudinally and the protruding portion, which is made to correspond in size with the diameter of the ileum, is excised with the cautery (Fig. 494, 2). The stump of the

ileum, which is held in a Kocher clamp, is then approximated to the defect in the colon and the anastomosis is begun. Using an atraumatic needle, a posterior running suture of No 0 chromic catgut is placed with a tie at the beginning and a lock at the end, leaving both ends long in order to tie them later at each end of the anterior suture (Fig. 494, 3). The clamps are then rotated inward and a continuous right angle (Cushing) suture is placed anteriorly with no tie at either extremity (Fig. 495, 4). The clamps are withdrawn as the assistant makes traction on one end of the suture to begin the inversion. The

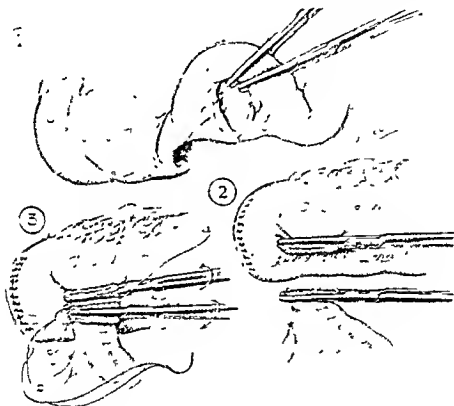


Fig. 494—Steps in end-to-side ileocolostomy. 1, Division of terminal ileum. 2 Kocher clamp on side of colon. 3, Posterior continuous suture of catgut.

operator completes the inversion by making traction on the other end of the anterior suture. Agglutination of the crushed ends of the bowel is depended upon to maintain closure until the inversion is accomplished. Corresponding ends of the anterior and posterior sutures are then tied (Fig. 495, 5). The long end of the posterior suture is continued around anteriorly and tied, forming a second anterior suture line (Fig. 495, 6). The continuity of the lumen is established by invaginating the walls of the ileum and colon with the thumb and forefinger. The anastomosis is reinforced posteriorly and at the angles with

in placing the sutures. After completing the suture continuity is established and the adequacy of the stoma is determined by invaginating the bowel on either side with the thumb and forefinger. The cut edges of the mesentery are approximated carefully to leave no defect or raw surfaces (Fig 497 5).

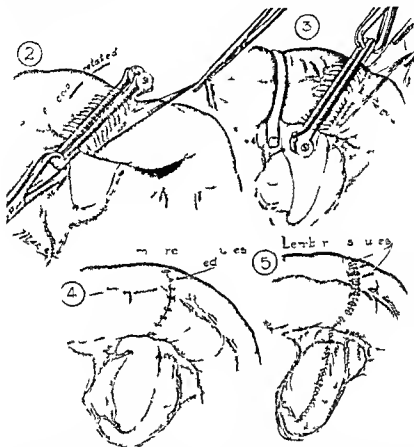


Fig 497—Steps in end to end aseptic anastomosis (continued). 1 Clamps rotated and first row of Halsted mattress sutures of silk placed. 2 First row of sutures tied and opposite row of mattress sutures placed. 3 Stone clamps removed and second row of mattress sutures tied. 4 Completed anastomosis. 5 Completed anastomosis.

CLOSURE OF THE WOUND

The exact method of closure of the wound has differed with individual operators. As a rule the peritoneum is closed with continuous No 0 or No 1 chromic catgut. The wound is thoroughly but gently irrigated with saline solution. The muscle and fascia closed with interrupted figure of 8 sutures of doubled No 000 black silk or of No 1

chromic catgut, and the skin with interrupted No. 0000 silk. In cases in which soiling has occurred the closure is usually made with 21 gauge silver wire stay sutures. These are placed through all layers of the abdominal wall, no suture material being used in the line of the incision.

POSTOPERATIVE CARE

The postoperative care is important, but usually not difficult. The operation is ordinarily not accompanied by much loss of blood or by shock. Intravenous injection of glucose and saline solution is given during operation and whole blood is substituted if indicated. Continuous gastric expression is usually maintained until the morning after the operation. The patient is placed in a position of comfort when recovered from the anesthesia and is turned from side to side at two hour intervals. Morphine is given as necessary to avoid pain and restlessness. Deep breathing exercises are encouraged and hyperventilation with carbon dioxide is effected at regular two and four hour intervals respectively throughout the first postoperative day. If a colostomy is present, water by mouth is started on the day after operation and a diet low in residue is given as soon as tolerated. If no colostomy has been provided small amounts of water only are given for the first forty-eight to seventy-two hours. The urinary output is maintained at a level of above 1000 cc. for each twenty-four hour period by parenteral hydration with glucose and saline solution if oral intake is not adequate. Daily requirements of vitamins B and C are satisfied.

COMMENT

Even though careful preliminary preparation designed to permit safe immediate anastomosis is employed, one is occasionally confronted with circumstances that force him to abandon primary anastomosis in favor of a Mikulicz or an obstructive type of resection. For example, the colon proximal to the lesion may be filled with inspissated stool despite antecedent colostomy and days of attempts to cleanse the bowel by irrigation. Another example of such a circumstance is the presence of an abscess secondary to perforation at the site of the lesion. Also the general condition of the patient after mobilization of the lesion may contraindicate further abdominal manipulation, and require an exteriorization procedure with obstructive resection. It must be admitted that methods of immediate anastomosis following resection for carcinoma of the colon are not suitable for anyone unwilling to pay exact attention to details of careful pre-operative, operative and postoperative management. Disregard may lead to complications, chiefly those of leaking of the suture line with peritonitis and intestinal obstruction.

Principles to be regarded in obtaining the best possible results may be enumerated

- 1 Preliminary correction of anemia and of disturbances in chemistry nutrition and hydration
- 2 Relief of obstruction and attempts at thorough cleansing of the intestine before removal of the lesion
- 3 Use of the abdominal transverse incision
- 4 Careful attention during resection of the mesentery to preservation of blood supply to the segments of bowel at and adjacent to the proposed site of anastomosis
- 5 Gentleness in the dissection and handling of the bowel and its mesentery
- 6 Adequate mobilization of the segments to be anastomosed in order to prevent tension at the line of suture
- 7 Precision in placing of sutures after careful preparation of the bowel to receive them Inverting mattress sutures should catch the submucosa but not penetrate the mucosa and should be tied just tight enough to hold serosal surfaces in apposition but must not strangulate the tissue Inversion of too much of a diaphragm is to be avoided
- 8 Accuracy in approximating the edges of the mesentery and in reperitonealizing denuded areas
- 9 Isolation of the field of resection and exclusion of contaminated gauze instruments towels and gloves from the field before reperitonealization and closure of the wound
- 10 The use of continuous gastric expression until obstruction is relieved and for the immediate preoperative and postoperative period
- 11 The provision of adequate hydration and nutrition and the prevention of atelectasis after operation

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SYMPOSIUM ON GENITOURINARY SURGERY

THE MANAGEMENT OF BLADDER TUMORS

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With the introduction of the various operating cystoscopes, electro-surgical units, radium deep roentgen ray therapy and improvements in surgical technic, tremendous strides have been made in the therapy of tumors of the bladder. In order to discuss the management of these tumors properly a brief consideration of their incidence, etiology, pathology and symptomatology is desirable.

INCIDENCE

In 1937, 32 per cent of deaths from cancer in the United States were due to carcinoma of the bladder.¹ There was no reduction five years later when the same percentage was reported. Tumors of the bladder are seen four times more frequently in males than in females.² Most of these are encountered in patients between the ages of 30 and 70, the majority being between 50 and 60 years old. The lower grades are more common in the earlier age group whereas the infiltrative, high grade malignancies are seen more often in older people.

ETIOLOGY

Little is yet known concerning the etiology of bladder tumors. Although there is no doubt that mechanical or chemical irritation plays some part, it is nevertheless well known that bladder calculi are rarely associated with tumors. Yet many urologists believe that chronic cystitis either with or without stones is a factor in the etiology of these neoplasms. It has definitely been shown that the incidence of bladder tumors is greater in aniline dye workers and that the irritation caused by the presence of the ova of *Bilharzia* in the bladder is a recognized causative agent. Since the majority of bladder tumors are located on or near the trigone, the area most subject to inflammation, it is conceivable that chronic irritation plays some role.

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PATHOLOGY

Most bladder tumors involve the trigone, neck or lateral walls of the bladder. The posterior wall, vault and anterior wall are less frequently involved. Practically all tumors encountered in clinical practice are of epithelial origin. Rarely are mesodermal tumors seen. These rarer growths can occur as *sarcomas*, *myomas* or *fibromas*.

The simplest form of epithelial tumor is the *papilloma*, which appears as a slender delicate, almost transparent papillary growth supported by a long pedicle projecting from the mucosa of the bladder. Although often referred to as a "benign papilloma," these tumors are nevertheless considered as of actual or potential grade I malignancy. The *papillary carcinoma* may not differ materially in appearance from the papilloma but it is more likely to be firmer in consistency and it develops on a shorter and more sessile base. These tumors are much more likely to be single than the simple papilloma and they undergo

large segment of the bladder

We find Broders' classification with respect to relative malignancy a convenient method of grouping bladder tumors, in addition to the impression obtained from observation of their gross appearance. Our experience has been that the clinical course of at least 90 per cent of bladder tumors can be accurately predicted from their Broders' grading when correctly reported. This is of great value in planning treatment in each individual case. On the other hand, it will be readily admitted that a small percentage of bladder tumors will not behave clinically as might be expected from their grading. Some feel that this is due to the presence of two or more tumors intimately associated with each other and of different degrees of malignancy. Thus, a low grade tumor might mask one of much greater malignancy in which case the patient's unfavorable course after treatment would be due to the underlying tumor of There are also some who believe that if there is following full cure of the original tumor but a new one and therefore capable of being of much greater or lesser malignancy than the original. Nevertheless since this percentage of atypical cases is small, we consider it well worth while to rely upon the microscopic grading of the tumor in planning treatment and in arriving at a prognosis.

Metastasis beyond the bladder wall itself occurs chiefly in high grade malignancy. The extension follows the regional lymphatic vessels from the base and lateral walls of the bladder throughout the pelvis and lower abdominal nodes. Rarely will the lesion metastasize to remote organs such as the brain, lungs or liver but this occasionally

occurs Bladder tumors can be malignant by position as well as by their microscopic characteristics and if the location of a tumor or multiple tumors involves the ureteric orifices, upper urinary tract obstruction with renal failure may result This can occur even after repeated fulguration of the tumor, as the scar tissue following treatment will itself produce ureteric obstruction Likewise, invasion of the bladder wall in the region of the ureteric orifices may also produce constriction and upper urinary tract obstruction Therefore, not infrequently patients with bladder tumors die of uremia before metastasis has become of clinical importance

SYMPTOMATOLOGY

The cardinal symptom of bladder tumors is *painless hematuria*, usually intermittent in character and frequently profuse The bleeding may be persistent or fleeting, that is, the patient may have blood in the urine once and then not again for several months or even longer Whenever tumors are allowed to grow to such size as to encroach materially upon the lumen of the bladder, *frequency* will result from the reduced bladder capacity This will also be true in cases in which infiltrating tumors cause contraction of the bladder with resultant reduction in capacity Tumors of long standing will cause secondary infection of the bladder with resultant *dysuria* Obstruction to urination or retention of urine will rarely occur when tumors are situated near the vesico urethral junction Symptoms due to metastasis or upper urinary tract obstruction rarely appear prior to the more obvious and localizing symptoms of hematuria or dysuria Localized symptoms are usually absent in abdominal and pelvic metastatic lesions unless the perineural lymphatics are involved Occasionally, invasion of bone structures in this area will cause pain

DIAGNOSIS

Any patient giving a past or present history of hematuria should have the benefit of a complete urologic study A careful *history* and complete *physical examination* are most important A catheterized specimen of the *urine* from the female patient and the second of a two glass specimen from the male patient are obtained for microscopic study The absence of red blood cells on microscopic examination in such cases should not deter further examination The total kidney function should be determined in all cases We use the *phenolsulfonphthalein function test* routinely except in the presence of gross hematuria We consider satisfactory a reading of 50 per cent or more in an hour and ten minutes after the intravenous injection of 1 cc of phenolsulfonphthalein We feel that this is evidence of at least complete compensation of kidney function whether or not finer degrees of change in renal function might be demonstrated by other more

sensitive tests The *prostate gland* in the male is then carefully palpated for possible evidence of malignancy and its secretion examined microscopically for infection

Cystoscopy is then performed and the entire bladder wall as well as the proximal portion of the urethra is carefully studied for evidence of tumor If bleeding is difficult to control at the time of cystoscopy or if bladder spasm makes it impossible for the patient to cooperate sufficiently to allow careful study of the bladder wall in the office the cystoscopic examination is done again in the hospital under spinal or general anesthesia A careful unhurried examination with good vision and good relaxation of the bladder is most essential in diagnosis It is easy to overlook a small or ulcerative tumor in the patient with constant bladder spasm during the examination or if bleeding prevents a clear field of vision After the tumor has been identified and its size and infiltrative qualities carefully estimated biopsy specimens are taken from several areas for microscopic study *Treatment of the tumor is postponed until this information has been obtained*

A number of nonmalignant lesions of the bladder can confuse the cystoscopist who suspects a tumor Chief among these is bullous edema which frequently appears similar to the relatively benign papillary forms of bladder tumor

with water while cystoscopy is this edema and reveal its true nature At other times it is to take a specimen for biopsy in order to differentiate one from the other Other confusing lesions include cystitis cystica tuberculous ulceration of the bladder alkaline incrustated cystitis leukoplakia vesical calculi covered with exudate and firmly attached to the bladder wall or inflammatory reactions resulting from radiation therapy previously administered in the female pelvis Extension into the bladder base from carcinoma of the cervix or rectum can occur because of the intimate lymphatic connection between these organs In such instances the tumor may have actually broken through with ulceration and this is easily recognizable or it may have produced only some elevation of the bladder mucosa with congestion and edema but no ulceration In the latter instance biopsy of the superficial layers of the bladder wall will not reveal the presence of a tumor even though it is actually present deep in the muscular layer of the bladder wall Endometriosis can occur in the bladder and produce hematuria usually following a pattern parallel to the menstrual cycle and when seen will be purplish and grapelike in appearance Such lesions may be accurately identified by biopsy and locally removed followed later by oophorectomy If diverticula of the bladder are encountered, it is always well to remember that a tumor may occur deep in a diverticulum beyond the field of vision of the cystoscopist In such in

stances cystograms may or may not be of aid in identifying the lesion but if blood is seen coming from a diverticular orifice, this diverticulum should eventually be removed with a presumptive diagnosis of tumor. In routine cases of bladder tumor cystograms are of further aid in revealing the presence of infiltration of the bladder wall with resulting distortion and reduction of capacity, thereby giving some indication as to the extent of the tumor as well as its degree of malignancy.

Rectal palpation of the bladder base above the prostate in the male and *vaginal examination* in the female will give evidence of the presence or absence of infiltration of the base. *Bimanual examination* of the bladder, preferably under anesthesia, with one finger in the rectum or vagina and the other hand pressing suprapubically will frequently give palpable evidence of an infiltrated bladder and also yield information as to the relative degree of fixation of the bladder which has already occurred. This information is of great value when partial or complete cystectomy is contemplated and may indicate in advance those cases which are operable.

Excretory urograms are made in every case in order to rule out possible primary malignancy in the upper urinary tract as well as to establish the presence or absence of obstruction on either side as the result of the tumor. If partial resection of the bladder is contemplated with the possible sacrifice of one kidney by ligating its ureter due to its location in the involved area, it becomes of vital importance to establish the presence of a normal kidney on the opposite side. Likewise, if uretero intestinal transplantation followed by cystectomy is contemplated, it is essential to establish the presence of normal ureters because ureters dilated by chronic obstruction from a tumor at the ureterovesical junction do not lend themselves well to intestinal implantation.

TREATMENT

Essentially, the treatment of all tumors of the bladder is their removal. The method by which this is accomplished depends upon many factors. Chief among these is the grade of malignancy of the tumor. Of great importance also are its size and location and the age and general condition of the patient. Also, as pointed out before, if radical operation is contemplated, it is always necessary to rule out, by bimanual palpation if possible, prohibitive fixation of the bladder by extension of the tumor beyond the bladder wall.

Transurethral or Suprapubic Fulguration and Resection; Radical.—Grade I papillary tumors are best treated, as a rule, by simple *transurethral fulguration*. It is our practice to use the Stern-McCarthy resectoscope for this purpose. This instrument allows the rapid cutting away of the great mass of the tumor or tumors followed by thorough

fulguration of the base. Since these tumors will not have infiltrated the bladder wall beyond the mucosa fulguration need not be deep. Occasionally such a tumor may have grown to such a size as to make it impractical to remove it transurethrally. This is also the case if the tumors are so great in number as to stud large areas of the bladder. *Suprapubic fulguration* of the open bladder is a more efficient and desirable method of handling these cases. Since these grade I tumors are notoriously recurrent in nature we make it a fixed rule to inspect these bladders in the office by cystoscopy every three months after the original tumor has been removed. Small recurrences seen here and there in the bladder not necessarily at the site of the original tumor can usually be fulgurated in the office with any satisfactory electro-surgical unit without the use of an anesthetic.

The grade II papillary carcinomas are likewise treated by transurethral resection and fulguration but we frequently supplement this with the application of radium. Radon seeds represent the most convenient means of applying radium. After resection these are implanted into the base of the tumor with an injector through an operating cystoscope. A sufficient number of seeds is ordered in each individual case to cover the entire base of the tumor. The radon seeds are calculated to deliver 1.25 millicuries at the time of implantation and are spaced approximately 1 cm apart.

Partial or Segmental Resection of the Bladder—For the more infiltrative higher grade malignancies (grades III and IV) we consider open *radical operation* necessary when possible. Although simple transurethral fulguration of such a tumor followed by irradiation either with radium or deep roentgen rays will occasionally bring about a spectacular result in such tumors it is felt that the margin of safety is too small and that the tumor itself as well as a generous portion of the remaining bladder wall if not all of it should be removed if possible. Here the age and general health of the patient are of prime importance. Partial or complete resection of the bladder is a rather arduous procedure which has to be carefully balanced against the normal life expectancy of the patient and the status of his general health. It is likewise of great importance to establish normal kidney function in cases in which radical operation is being considered. Should it be possible to demonstrate clinically that the tumor has extended beyond the bladder or that it had invaded the ureters then more conservative procedures would seem to be indicated. Here again transurethral resection of the tumor followed by irradiation therapy seems the most desirable treatment.

In favorable cases however wide excision is preferable. If the tumor is located on the vault and is easily accessible partial resection of the bladder without disturbing the trigone or ureters is indicated. The usual low midline incision is made under spinal or general anes-

thesia, the muscles and fascia divided, the bladder insufflated so as to make it more accessible and the peritoneal fold reflected upward off the bladder. Should the tumor be found to have invaded the peritoneum where it is attached to the bladder, this portion of the peritoneum should be resected away along with the bladder wall itself and the defect repaired afterwards. The bladder is opened then and the contemplated area of resection carefully mapped out and cut away with the electrosurgical knife, the bladder is then resutured in two layers with chromic No. 1 catgut and a large Pezzet catheter left in. Drains are placed beside either side of the bladder and the wound closed in layers. Should the tumor be found to extend down one lateral wall far enough to make it desirable to carry away one corner of the trigone including the ureteric orifice on that side, this ureter may either be reimplanted into the bladder or deliberately tied off, thereby sacrificing the kidney. In such cases, one will always have determined the presence of a normal kidney on the opposite side and therefore the sacrifice of one kidney is not necessarily objectionable. This shortens the time of operation and obviates the danger of failure of reimplantation in a bladder which is already considerably mutilated by resection of the tumor. Except in the cases in which the kidney to be sacrificed is infected, it will be found that tying off this ureter does not complicate in any way the postoperative course of the patient. If infection is present in such a kidney, sepsis will follow and this kidney can then be promptly removed when the symptoms of infection become obvious. We feel that postoperative irradiation by deep roentgen ray in these cases is a valuable adjunct to treatment.

Bilateral Uretero-intestinal Anastomosis and Complete Cystectomy.—In those cases of high grade malignancy which do not lend themselves to partial or segmental resection of the bladder and yet show no gross evidence of metastasis, *complete cystectomy* is indicated (Fig. 498). A necessary prerequisite to cystectomy is diversion of the urine. This is best accomplished by bilateral uretero-intestinal anastomosis. If this should for any reason be impractical, bilateral cutaneous ureterostomy can be done. However, this is not as desirable from the standpoint of the patient as the former and is only indicated, as a rule, in instances in which dilatation of the ureters makes it difficult or impossible to implant them into the intestinal wall.

It is our practice to do the intestinal anastomosis and cystectomy in two stages. The first stage consists of the implantation of the right ureter into the sigmoid. After the patient has fully recovered from this procedure (usually in about two weeks), we proceed with implantation of the left ureter followed by total cystectomy at the same time. At the time of the first implantation it is possible to explore the bladder and adjacent structures so as to be sure that the bladder is freely

movable and that cystectomy will therefore be feasible. A further consideration at this point is the fact that even if some evidence of metastasis is present, cystectomy may still be desirable if mechanically possible for the reason that the patient's future course will be far more comfortable without having to contend with a sloughing tumor and an irritable spastic bladder during the remainder of his life. Furthermore, postoperative irradiation in such cases may have a favorable influence on those metastases present to the extent that the operation becomes worth while.

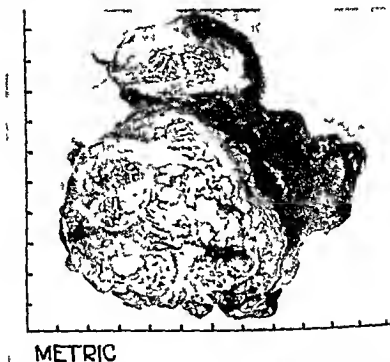


Fig. 498—Specimen of infiltrating carcinoma of bladder after total cystectomy.

Preoperative Preparation—Prior to operation the patient is hospitalized and an intestinal antiseptic and nonresidue diet are given. Sulfasuxidine (3 gm. four times daily) is administered in an effort to sterilize the intestinal tract partially. Twenty-four hours before operation a laxative is given and enemas are ordered for the night preceding the operation and the morning of operation. A rectal tube is left in place after the last enema and the patient is taken to the operating room. Parenteral fluids and whole blood should be freely given during the operation to prevent shock and fluid loss.

First Stage—We prefer the Coffey type 1 procedure for uretero-intestinal anastomosis as modified by Mayo.³ The right ureter is trans-

planted first. A longitudinal incision is made to the right of the midline, the muscles and fascia are divided and the peritoneum opened. The patient is placed in the Trendelenburg position and the intestinal mass is packed off. The sigmoid is mobilized and an area as far down toward the rectum as possible is prepared for anastomosis. This is important as it leaves the remaining portion of the sigmoid above free of adhesions so as to be more easily handled later on for the second anastomosis. After the point of bowel to be used has been determined, this area is isolated with an intestinal clamp for a distance of several inches with one of the longitudinal bands presenting. The ureter is then identified through the parietal peritoneum, a small window made

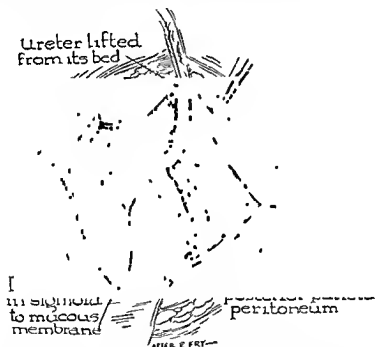


Fig. 499—Mobilization of ureter prior to transplantation

in the peritoneum and the ureter dissected free (Fig. 499). It is divided and ligated close to the bladder and the proximal end then brought up to the intestine. This end is cut obliquely and then split longitudinally for about 1 cm. in order to avoid stricture of the end of the ureter later. An atraumatic No. 0 chromic suture is taken through each of the flaps thus created by cutting the distal end of the ureter. The bowel wall is then incised along the longitudinal band for a distance of about 5 cm. going down to but not through the mucosa. The muscularis and serosa are then carefully dissected laterally on each side in order to provide a free flap to close over the ureter later on. An incision is then made through the mucosa at the distal end of this trough and each of the previously prepared catgut

sutures passed through the bowel and then out at a distance of at least 3 cm below this opening. A small piece of catgut is placed in

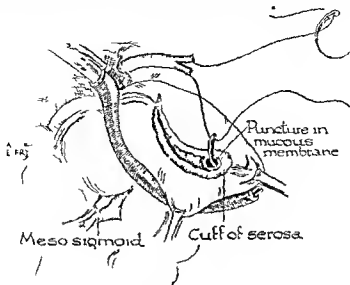


Fig 500—Transplantation of ureter into sigmoid

the open end of the ureter in order to keep it open temporarily and the ureter is then passed down into the intestinal lumen (Fig 500)

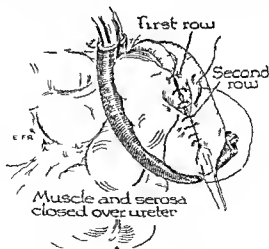


Fig 501—Closure of muscles and serosa of sigmoid after ureter has been transplanted

The sutures previously taken are tied on the outside. The ureter is then buried in the bowel wall for the entire length of the trough by

atraumatic catgut sutures in the flaps previously prepared. Occasional small bites are taken through the outer coats of the ureter as the sutures are put in so as to anchor it further in position. Several layers of sutures are taken in all, completely burying the ureter (Fig 501). When the operation is finished, the ureter should not be under any tension and should present itself in a straight line coming down from the kidney and entering the bowel. This area of intestine is then rotated slightly and the edges of the posterior peritoneum, previously opened for access to the ureter, are sutured to the intestinal wall so as to extraperitonealize the field of operation. The peritoneum is closed with catgut and the wound is closed in layers, with catgut for the muscle and fascia and silkworm and dermal for the skin.

Postoperative Care—The patient is given parenteral fluids up to 3000 cc a day. A rectal tube is kept in place, no laxatives are given and suitable urinary antiseptics may be administered. In the presence of undue fever or tenderness over the right kidney during the post-operative period we administer one of the sulfonamides in doses of 0.5 gm four times a day with sodium bicarbonate, or the elixir of mandelic acid.

Second Stage—After the patient has sufficiently recovered, usually in about two weeks, excretory urograms are made in order to demonstrate the presence of a normally functioning kidney on the side of the first operation and if all is well, the second stage is planned. Should this right kidney fail to function or continue to give evidence of obstruction and infection in the form of pain and fever, the second stage can be postponed or abandoned. We feel that this is the chief virtue in doing a two-stage operation, in addition to lessening the shock and operating time for the second stage.

In the second stage the left ureter is first transplanted by the same technic previously described for the right. As mentioned before, the upper portion of the sigmoid will be found freely movable and easily accessible for this purpose. The incision here should be to the left of the midline. The peritoneum is then dissected completely off the bladder wall if possible but if it has been found that the tumor has invaded the peritoneum, that portion of the peritoneum is taken along with the bladder and the defect in the peritoneum repaired. Then, dissection of the bladder from above is begun, the lateral and posterior aspects of the bladder are gradually freed and the vesical arteries clamped, divided and ligated with transfixion sutures of chromic No. 2 catgut as they are encountered. The ureteral stumps are identified and pulled up. The vas deferens on each side is likewise clamped and ligated. The base of the prostate and seminal vesicles are freed from the rectum and the prostate then dissected free on both sides by blunt dissection with the finger. The urethra is clamped at the apex of the prostate and the entire specimen including the

bladder prostate and seminal vesicles removed. The urethral stump is transfixed by chromic No 2 catgut and any bleeding encountered in the prostatic plexus of veins is controlled by mattress sutures. If convenient a stab drain opening is made through the perineum to the outside in order to provide dependent drainage for the large cavity left after removal of the bladder. Cigarette drains are likewise placed down to the base of the wound coming out from the lower angle of the incision and the wound closed in layers with catgut for the muscle and fascia and silkworm and dermal for the skin. Here again a rectal tube is left in place and intravenous fluids and whole blood are given to insure an adequate intake and to prevent shock.

We have found penicillin of value during this postoperative period as it seems to promote wound healing and retard secondary infection. It is usually given by intramuscular injection of 20 000 to 30 000 units every three hours. Deep roentgen ray therapy over the lower abdomen is considered a valuable adjunct to treatment after the wound has completely healed.

CONCLUSIONS

1 Painless hematuria should be considered presumptive evidence of malignancy in the urinary tract until proved otherwise.

2 Cystoscopy offers a certain means of diagnosis of bladder tumors and should be accompanied by biopsy with microscopic grading of the specimen since the plan of treatment will largely depend upon the grade of the tumor.

3 Transurethral excision and fulguration with or without some type of irradiation therapy is the treatment of choice for those bladder tumors of low grade malignancy.

4 Experience and refinements in surgical technic have made radical excision of highly malignant bladder tumors less dangerous than ever before.

5 Wide resection of highly malignant tumors offers the greatest promise of cure and should be the treatment of choice in all such cases which are considered operable.

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COTTON SUTURES IN VAGINAL PLASTIC OPERATIONS ABOUT THE BLADDER AND URETHRA

CONRAD G. COLLINS, M.D., F.A.C.S.*

In 1939 Meade and Ochsner¹ demonstrated the superiority of cotton over any other absorbable or nonabsorbable material available for use as sutures. Since then numerous reports have appeared in the literature stressing the advantages of cotton for this purpose. In 1942 we² reported a series of cases in which gynecologic and obstetrical operations had been performed with cotton as the suture material. Since that time we have used cotton sutures exclusively in gynecologic and obstetrical surgical procedures whether the operation was performed abdominally or vaginally.

ADVANTAGES OF COTTON SUTURES

In vaginal plastic repair the advantages of cotton sutures include (1) minimal reaction in the tissues, (2) diminished amount of postoperative vaginal discharge and (3) increased comfort for the patient. Its use also permits early ambulation and a subsequent decrease in the number of urologic complications such as cystitis or pyelitis by 85 per cent.² Early ambulation and lack of tissue reaction reduce the necessity for postoperative catheterizations in a large number of patients. Furthermore, earlier postoperative and postpartal examination is possible because the patient experiences less pain on vaginal or speculum examination when cotton sutures have been used than when other material is utilized. When cotton has been employed, it is possible to examine a woman vaginally or with a speculum after the second or third postoperative or postpartal day with little or no discomfort. We have noted less scar tissue about the vagina months after operation with cotton sutures than with any other absorbable suture material. In addition, the vagina, bladder, rectum and urethra are adequately supported and the tissues are much more pliable and plastic instead of being rigid as in cases in which nonabsorbable sutures have been used.

This communication will be limited to the use of cotton sutures in the repair of cystocele, urethrocele, vesicovaginal fistula and urethral diverticulum.

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PREOPERATIVE CARE

Plastic operations in women who are still within the menstrual age are best performed within the first two weeks following a menstrual period. In this way considerable undesirable oozing or bleeding can be eliminated. As in all surgical work the patient should be brought to the operating table in the best general condition possible. The blood count and hemoglobin should be within normal limits and for weeks before the operation the patient's diet should include adequate proteins and vitamins especially vitamin C since normal serum protein and vitamin C have been shown to promote wound healing.

In women who have reached the climacteric the vaginal mucous membrane because of the lack of estrogenic hormones reverts to the type found in the preadolescent period that is there are atrophic changes manifested by a thin epithelium usually six to eight layers of cells deep containing little or no glycogen. The atrophic membrane and lack of glycogen predispose to vaginal infection produced by pathogenic organisms and in addition it is technically more difficult to dissect a very thin and atrophic mucous membrane from the underlying tissues. These two objectionable features can easily be remedied by the use of estrogenic suppositories administered nightly for three weeks prior to the date of operation the dosage being 2000 to 2500 international units of estrogenic substance either in the form of natural estrogen or 0.5 mg. of stilbestrol in suppositories. The preoperative use of suppositories containing estrogenic hormone converts the atrophic mucous membrane to the type found in the healthy young woman that is the membrane becomes twenty four to twenty six layers of cells in thickness the cells contain an adequate amount of glycogen and the vaginal pH and flora are reestablished to an optimal condition. It is our impression although this has not been substantiated by biopsy that not only is the vaginal epithelium affected by the use of estrogenic suppositories but the underlying pubocervical fascia seems to be thickened and tougher and more adaptable for suturing.

OPERATIVE TECHNIQS

In regard to nonabsorbable suture material in surgical procedures the principles set down by Halsted should be followed unequivocally that is there must be thorough hemostasis the suture material should be as fine as compatible with tissue strength fine bites should be taken mass ligation of tissue should be avoided and the suture should be cut close to the knot. Deviation from these tenets will of course produce undesirable results.

At the operating table the vagina is thoroughly scrubbed with green soap and water the excess water is removed by means of alcohol and the vagina and vulva are painted with any antiseptic solution the

operator prefers. After thorough cleansing with green soap and water and alcohol the use of an antiseptic solution about the vagina and vulva is of questionable value.

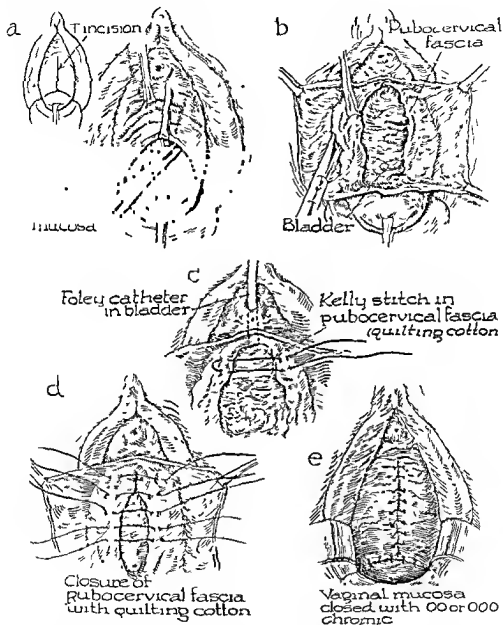


Fig 502.—Technic in repair of cysto-urethrocele. For details, see text.

Cystocele.—In the repair of cystocele a linear incision down the midline or a deep T-shaped incision is made through the vaginal mucous membrane (Fig 502, *a*). The vaginal mucosa is then reflected from the pubocervical fascia and bladder by means of initial sharp dissection with a small scalpel blade. This dissection is continued

widely on either side from the midline with scalpel or scissors (Fig 502 *b*) and the bladder is fully mobilized. A Foley catheter is inserted into the bladder and the bladder neck identified. A Kelly stitch of quilting cotton is then placed in the pubocervical fascia in the region of the bladder neck and tied (Fig 502 *c*). The pubocervical fascia is then brought together with interrupted sutures of quilting cotton placed approximately 0.75 cm apart (Fig 502 *d*). The sutures are tied and then cut at the knot. Occasionally in very large cystoceles in elderly women two rows of sutures are used. The excess vaginal mucosa is trimmed away and the

lined with No. 00 or 000 chromic gut is used in the vaginal mucous

to have to remove sutures from this structure postoperatively or postpartally. We have used very fine cotton sutures in the vaginal mucous membrane (cotton No. 150 or 200) in humans and observation of these patients for months after operation has shown that ultimately the suture is either absorbed or has slipped out aseptically. However for purposes of convenience we do not use cotton in the vaginal mucous membrane itself although there is no surgical contraindication to its use in this structure.

Urethrocele—The vaginal mucous membrane over the urethra is divided in the longitudinal axis of the vagina down to the urethra or pubocervical fascia (Fig 502 *a*). The dissection is carried out widely laterally and the urethra is freed along its entire course. Any adhesions to the pubic arch are separated by sharp dissection. A catheter preferably of the Foley type is inserted into the bladder to identify the bladder neck. A first layer of Kelly stitches of interrupted quilting cotton is placed at the bladder neck (Fig 502 *c*) and then a second layer of interrupted quilting cotton sutures is placed through the pubocervical fascia. The sutures are spaced anywhere from 0.3 to 0.5 cm apart. The vaginal mucous membrane is then approximated with chromic No. 00 or 000 catgut.

In plastic operations in which cystocele and urethrocele coexist the technic outlined previously is used, i.e., a longitudinal incision or inverted T shaped incision is made through the vaginal mucosa extending from just below the urethral orifice to the cervix. Whether or not a T shaped incision is used or just a single longitudinal incision depends upon whether or not the cystocele extends down to the region of the internal os of the cervix. There is no need for a T shaped incision in cases in which the cervix and uterus have been removed or *the cystocele does not involve the cervix*. The remainder of the procedure is as described under the correction of cystoceles and urethroceles.

Vesicovaginal Fistula—The end results in cases of vesicovaginal fistulas depend upon (1) the amount of mobilization obtained at the

time of operation and (2) the ability to approximate the bladder mucosa and pubocervical fascia without tension. Accordingly, irrespective of the site or cause of the fistula, we believe it best to make an initial incision down the midline (Fig 503, *a*) extending from just beneath the urethra to the cervix or to where the cervix would have been should it have been removed at a previous operation. If the fistula is in the midline, it is encircled and the bladder is freed by means of wide dissection to the most lateral portion of the vaginal

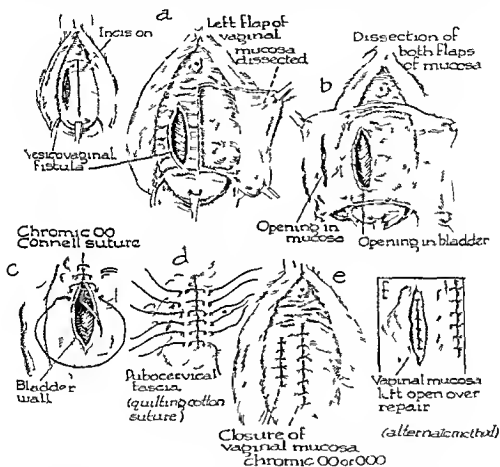


Fig 503—Technic in repair of vesicovaginal fistula. For details see text

wall. Should the fistula be on either the right or the left side and not in the midline, the bladder is first freed on the side opposite the fistula, that is, if the fistula is on the right side the left side is dissected first and vice versa (Fig 503 *a*). The bladder is freed to the most lateral portion of the vaginal wall. The dissection is then carried to the side on which the fistula exists (Fig 503 *b*), the fistula encircled and the vaginal mucous membrane reflected from the bladder or pubocervical fascia as far laterally as possible. In this manner we are able to obtain maximum mobilization of the bladder and conse-

quently a suture line which will be under minimal stress irrespective of the location of the fistula. The margins of the fistulous opening into the bladder are then freshened, the scar tissue cut away and the bladder mucous membrane approximated by a Connell suture of chromic No. 00 or 000 (Fig. 503, *c*). Nonabsorbable suture material is not used to close the bladder mucosa. A second line of sutures consisting of interrupted quilting cotton is placed through the pubocervical fascia and/or bladder muscularis about 0.5 cm. apart (Fig. 503, *d*) and the bladder mucosa and/or pubocervic

suture line in the bladder mucosa

in a second row of cotton sutures. Advantages over larger sized catgut or sutures such as stainless steel wire or silver wire in this particular part of the operation as cotton sutures of this size will break before one can tie them under tension, which is not true of stainless steel or silver wire. Thus, closure of the bladder muscularis and/or pubocervical fascia over the suture line in the bladder mucosa guarantees that the suture line is not tied under tension, this greatly enhances the possibilities of healing. The vaginal mucous membrane down the midline is then closed with chromic No. 00 or 000 sutures (Fig. 503, *e*). Whether or not the vaginal mucosa is closed over the site of the fistula is of little or no import. If the mucous membrane can be brought together without tension then it is closed with interrupted chromic No. 00 or 000 sutures. If the defect is so large that it cannot be closed, or cannot be closed without undue tension, the mucous membrane is not closed (Fig. 503, *f*). Thus, the cardinal principles involving the healing of vesicovaginal fistulas have been fulfilled, that is (1) wide mobilization of the bladder to insure a suture line which is tied without tension and (2) closure of the fistula in layers without tension. We believe that this approach to the closure of vesicovaginal fistulas far surpasses the direct attack on the fistula itself. To reiterate the approach to closure should be (1) an initial line of incision down the midline of the vaginal mucosa, (2) free mobilization on the uninvolved side first and (3) the bladder near the fistula mobilized as a latter part of the operation.

Postoperatively, a retention catheter of the Foley type is put in the bladder, the patient placed on a Bradford frame on her abdomen and the catheter connected to a bottle on the side of the bed. The catheter is removed on the twelfth or fourteenth postoperative day. Vaginal suppositories of estrogenic substance either 0.5 mg. of stilbestrol or 2000 international units of natural estrogen, are inserted into the vagina twice daily to promote healing especially in cases in which it was not possible to approximate the vaginal mucosa over the site of the fistula. This insures more rapid growth of the epithelium over the defect.

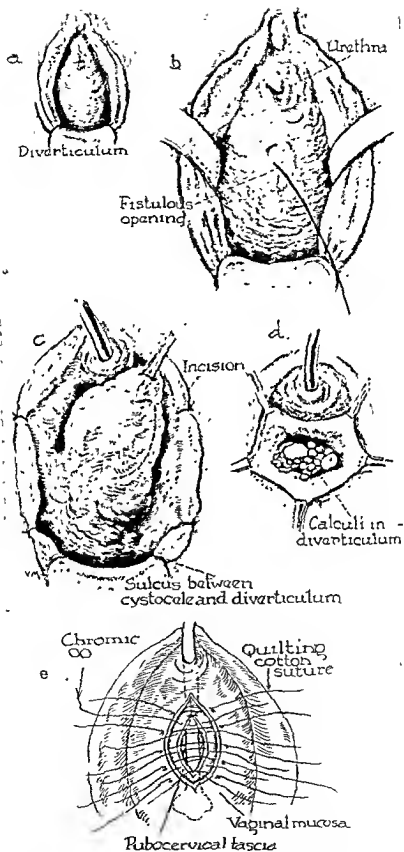


Fig. 504.—Technic in repair of urethral diverticula. For description, see text.

Diverticula of the Urethra—Although this condition is rarely encountered its possible presence should always be kept in mind. Diverticula may vary in size from 1 cm to 10 cm in diameter and may or may not contain calculi. The differentiation of diverticula from urethroceles and cystoceles is not difficult if the condition is kept in mind and when suspected if a urethral sound or small endoscope is placed into the urethra the diverticulum can be palpated over the sound or endoscope. The diagnosis of urethral diverticula associated with stones is especially easy as the stones give a typical "chicken crow" feel.

Technic—An incision is made just below the urethral meatus down the midline as far posteriorly as necessary (Fig 504 c). The bladder mucosa is dissected away from the wall of the diverticulum and the diverticulum opened. It is then excised (Fig 504 d) and the urethral wall closed with interrupted chrome No 00 or 000 sutures. The vaginal mucous membrane is then closed over the suture line in the urethra by means of quilting cotton interrupted sutures (Fig 504 e). A retention catheter is left in place from twelve to fourteen days and then removed. The quilting cotton sutures are removed from the anterior vaginal wall at the same time. Occasionally the diverticulum is so large and contains so many stones that an actual erosion and fistulous opening are found in the diverticulum (Fig 504 b).

POSTOPERATIVE CARE

We do not advise or use vaginal packs postoperatively. The patient is allowed out of bed as soon as the effects of the anesthetic have disappeared and she is encouraged to walk about and to remain out of bed for as long periods as possible. In this way earlier spontaneous emptying of the bladder is obtained, the incidence of postoperative thrombophlebitis and phlebothrombosis is greatly decreased and in general the patient feels better. No vaginal douches are used unless the patient has a discharge. This is the exception in cases in which cotton sutures have been utilized. In patients who have reached the climacteric suppositories of estrogenic substance (2000 to 2500 international units) are used each night postoperatively for three to four weeks. This undoubtedly aids in wound healing.

CONCLUSIONS

1. Before plastic operations about the bladder and urethra are performed patients should have the following preoperative preparation: (a) Infections in the urinary tract should be eliminated by means of sulfonamides, penicillin or both. (b) In women who are still within the menstrual age correction of pathologic conditions should be attempted only within the first two weeks following a menstrual period.

because during this time the chances of excessive oozing are minimal (c) For the patient in the postmenopausal age or at the menopause when the vaginal mucous membrane has become thin and atrophic, the preoperative use of suppositories of 0.5 mg of stilbestrol or 2000 international units of natural estrogen in oil each night for three weeks greatly increases the thickness of the vaginal mucous membrane and the pubocervical fascia, makes dissection easier and aids in eliminating any infection which may accompany senile vaginitis

2 The use of quilting cotton sutures in the bladder wall or pubocervical fascia not only results in a neater operation but definitely decreases the amount of postoperative pain and vaginal discharge and reduces the necessity for postoperative catheterization because of early ambulation

3 Retention catheters should be used only in patients who have had repair of a urethral diverticulum or vesicovaginal fistula

4 In postmenopausal or menopausal patients the postoperative use of suppositories hastens wound healing

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CLEARANCE AND SATURATION TESTS OF RENAL FUNCTION

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With the possible exception of the eye, no organ in the human body lends itself so well to mathematical treatment as does the kidney. In the 100 years which have elapsed since William Bowman's famous observations laid the groundwork for studies in renal physiology, clinical research in this field has brilliantly justified itself. The purpose of this paper is to describe briefly and without full historical background the methods which yield quantitative renal function values of remarkable accuracy in the intact human body.

RATE OF GLOMERULAR FILTRATION

Rehberg¹ was the first to point out that the rate of glomerular filtration could be measured if there were available a substance which passes freely across Bowman's membrane but does not traverse the tubular epithelium in either direction. Thus, if a beaker containing 1000 cc of a 1 per cent salt solution is allowed to evaporate until the final volume is 100 cc, the final saline concentration becomes 10 per cent (concentration \times volume = concentration \times volume). Figure 505 illustrates the application of this principle to a single nephron in which the volume of glomerular filtrate is large and that of the bladder urine small, the tubular cells reabsorb water but leave the number of dissolved molecules unchanged.

If three of the four factors are known, the fourth is easily calculated. Wishing to determine the volume of glomerular filtrate formed per minute, we rearrange the equation to read $V = \frac{C_1 V_1}{C}$. The two items in the numerator are supplied by determining the concentration of the test substance in bladder urine and the rate of urine flow per minute. The denominator is procured indirectly, we cannot obtain glomerular filtrate from an intact animal but the requirement has already been made that the concentrations in plasma and glomerular filtrate are identical so that we have only to analyze a sample of venous plasma to obtain an equivalent figure. Substituting plasma (P) for glo-

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merular filtrate and using more familiar symbols, the equation becomes V (glomerular filtration rate) $= \frac{UV}{P}$. This is equivalent to

stating that $V = \frac{\text{mg. excreted per min.}}{\text{mg. per cc. plasma}}$.

The actual application of this principle to the patient is none too difficult. An adequate and reasonably constant concentration of the test substance in the blood stream is maintained by appropriate intravenous or subcutaneous injection, a catheter is placed in the bladder and, after a suitable period of equilibration, urine collections are

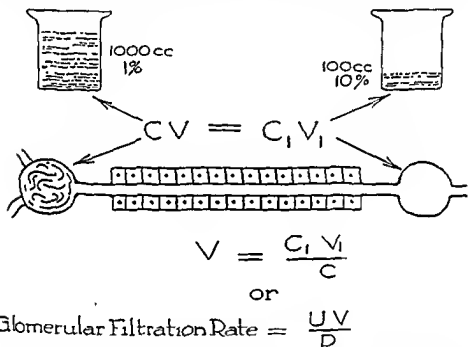


Fig. 505.—Illustration of the principles whereby the rate of glomerular filtration may be measured in intact subjects. See text.

made at arbitrary intervals by washing the bladder out with saline. Usually three or four twenty-minute periods are obtained and blood samples are withdrawn from the antecubital vein at the middle of each collection period. Details concerning the precise procedures are available.²

No substance which occurs naturally in the human body meets the requirements so that foreign materials must be employed. Of these, inulin is most widely used. Introduced independently by Richards and co-workers³ and Shannon and Smith,⁴ it has received the widest acceptance.⁵ The more recent demonstration that other substances (hexitols,⁶ thiosulfate⁷) yield identical results substantiates the current belief that the rate of glomerular filtration can be measured with great

accuracy in the intact normal subject. The problem of the diseased kidney will be referred to later.

The establishment of this technic for measuring the rate of glomerular filtration has been of the utmost theoretical and practical importance, but the formula which makes it possible may also be usefully applied to the study of any other urinary constituent since it $\left(\frac{UV}{P}\right)$ is essentially a concentration ratio $\left(\frac{U}{P}\right)$ to which a time factor (V) has been added. It is now the custom to express the excretion rate of any substance in relation to its plasma (or whole blood) concentration, and results may be grouped into those substances which are excreted (a) less and (b) more efficiently than inulin.

SUBSTANCES EXCRETED LESS EFFICIENTLY THAN INULIN

All the constituents of normal urine belong to this category with the possible exception of creatinine. The fact that the exact chemical

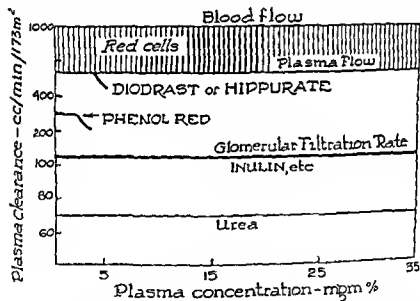


Fig. 506—The relationship between renal blood flow and the plasma clearance of various substances

nature of the chromogenic substances which react with the Jaffe reagent are unknown makes creatinine a difficult material with which to work. Differences of opinion on this matter exist⁸ and it would serve no useful purpose to include creatinine in the present discussion.

Figure 506 depicts the application of this formula to a representative number of substances. Smith,⁹ who has had the largest expe-

ence in this matter, reports that the glomerular filtration rate in normal man averages 131 cc per minute. For the sake of simplicity, however, and because other observers have found somewhat lower values, the normal volume of glomerular filtrate is put at 120 cc per minute.* When the excretion of another substance is studied in the same manner and the answer turns out to be less than 120, it may be assumed that that substance has been eliminated by a process of glomerular filtration and subsequent tubular reabsorption. In any event, it is unnecessary to invoke tubular secretion as an explanation for its appearance in the urine. If, however, the figure for a third substance is greater than 120, it is certain that a portion of this material must have been extruded into the tubular lumen by active vital processes residing within the tubular cells. Obviously, tubular reabsorption diminishes the efficiency of renal excretion and tubular secretion enhances it.

As examples of the manner in which naturally occurring substances are handled by the kidney, glucose and urea may be chosen. Since glucose is known to occur in glomerular filtrate in the same concentration as in plasma¹⁰ and since normal urine is glucose free, tubular reabsorption must be complete. When the formula is applied to urea, however, the average for normal adults is about 75 cc per minute,¹¹ a finding which must mean that approximately 40 per cent of that amount of urea which is filtered is reabsorbed by the tubules. Other naturally occurring substances, the excretion of which have been studied by current methods, are sodium chloride,¹² sulfate,¹³ phosphate,¹⁴ amino acids,^{15 16 17 17a} hemoglobin,¹⁸ vitamin C,¹⁹ beta-hydroxybutyric acid,²⁰ pantothenic acid,²¹ lactic acid^{21a} and uric acid.²² All these substances have been found to be excreted by a process of glomerular filtration and subsequent tubular reabsorption.

SUBSTANCES EXCRETED MORE EFFICIENTLY THAN INULIN

Of greater physiologic interest are certain foreign substances whose rates of renal elimination are high because bodily conservation is useless or harmful. In order to increase the efficiency of the excretory process, the kidney may modify its normal machinery in two ways. First, tubular reabsorption may diminish or cease altogether, in which event the excretion rate will approach or become equal to the rate of glomerular filtration. Secondly, an extra moiety may be added to the urine by a process of active tubular secretion. Figure 506 also

* By way of illustration, this figure would have been achieved by maintaining plasma inulin concentration at 20 mg per cent and finding that when urine was formed at the rate of 2 cc per minute the urinary concentration of inulin was

$$1200 \text{ mg per cent } \left(V = \frac{1200 \times 2}{20} \right)$$

illustrates the manner in which certain substances are excreted by this double process of glomerular filtration and tubular secretion

Phenol red (phenolsulfonphthalein) was one of the first such materials to be studied. In 1923 Marshall and Vickers³ first proved the existence of tubular secretion in dogs by showing that much more phenol red appeared in bladder urine than could possibly be accounted for by glomerular filtration alone, and it is now agreed that if tubular secretion did not exist, the rate of glomerular filtration in man would have to be at least as high as 350 cc per minute in order to account for all the dye excreted. This is regarded as an impossible figure, and still other substances (diodrast, hippuric acid derivatives etc.) have been shown to be excreted approximately twice as efficiently as phenol red.⁴

The importance of these studies lies in the fact that they provide at least a theoretical way of measuring the renal blood flow in intact subjects. This conception is best illustrated by a consideration of the so called *extraction ratio*. It is not difficult to explant a dog's kidney just under the skin to a position which permits withdrawal of blood from the renal vein at will. Blood obtained simultaneously from a peripheral vein is regarded as chemically equivalent to the blood entering the kidney through the renal artery and the formula $\frac{A-V}{A}$ rep-

resents the ability of the kidney to extract a given substance from the blood which perfuses it. Recently, extraction ratios have been obtained in man by passing a catheter up the median basilic vein, through the right axilla, down the inferior vena cava and into the renal vein itself.^{2a} If the concentration of substance X in peripheral vein plasma is 12 mg per cent and in renal vein plasma 9 mg per cent the extraction ratio is $\frac{12-9}{12} = 25$ per cent, the kidneys are

eliminating one quarter of the material brought to them.

If, then, a substance could be found the extraction ratio of which is 100 per cent (i.e. all the material is removed from the blood during one circulation through the kidney), measurement of its urinary excretion rate in relation to the blood concentration would give a figure equal to the rate of renal blood flow, since it is obviously impossible for the kidneys to eliminate more of the substance than is brought to them by the blood stream per unit of time. Figure 507 shows diagrammatically the approximate extraction ratios of representative substances in normal man and their direct proportionality to the $\frac{UV}{P}$ values.

Physiologists have therefore searched for substances which are excreted so efficiently that virtually none escapes the kidney by way

of the renal vein and presumably also the lymphatics. Figures 507 and 508 show that diodrast and certain hippuric acid derivatives virtually meet the requirements, since their extraction ratios in man are approximately 90 per cent.²⁴ The fact that the ratios are not 100 per cent is not a valid criticism for it, as Smith²⁶ has pointed out that some of the blood entering the renal artery is distributed to connective or fatty tissue and thus never comes in contact with true kidney parenchyma at all. The method has, therefore, been described as a measure of "effective renal blood flow." For example, if it be found that 1100 mg of diodrast are appearing in the bladder urine per minute and that peripheral vein plasma contains 2 mg per cc, then

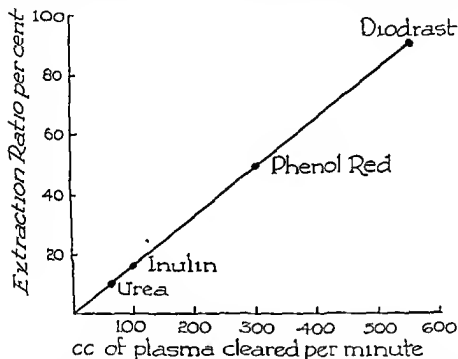


Fig 507—The relationship between plasma clearance and extraction ratio

550 cc of plasma must have come in contact with tubular tissue each minute. If, furthermore, the hematocrit is 45 per cent, the effective whole blood flow is $\frac{550}{0.45} = 1222$ cc per minute. In twenty normal human subjects Bradley²⁷ has found that the extraction of *p*-amino-hippurate ranged from 89.5 to 95.6 per cent with an average figure of 92.4 per cent.

It will be observed from Figure 506 that this technic is valid for the measurement of renal blood flow only when the blood concentrations are kept low enough to permit maximal extraction, the capacity of tubular cells to transmit material is easily exceeded and, when this is done, the extraction ratios obviously fall.

the amount of free or filtrable diodrast in 1 cc of plasma by the glomerular filtration rate, he obtains a figure representing the absolute quantity of diodrast filtered per minute, the difference between this and the total rate of diodrast secretion, of course, gives the tubular contribution. It is this latter value which is of such interest because of its quantitative limitation.

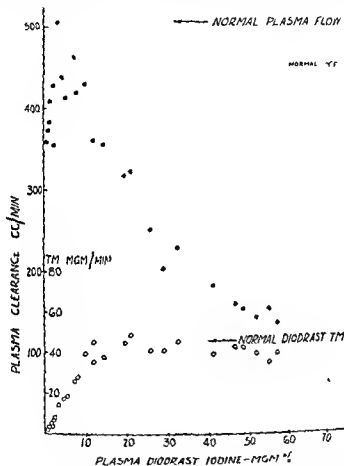


Fig 508—The relationship between plasma concentration plasma clearance and tubular excretion of diodrast iodine in a normal human subject

Figure 508 shows the relationship between the concentration of plasma diodrast and the amount secreted by the tubules of a normal human subject. The open circles represent the milligrams of diodrast iodine secreted per minute and show that at a plasma level of approximately 51 mg per cent this value becomes constant and that the tubules are unable to secrete more than 45 mg of diodrast iodine per minute regardless of further increases in the load of diodrast.

offered to them. This value has been termed by Smith *diodrast-T_m* (the maximal rate of tubular excretion), and may be accepted as one method of estimating the functional capacity of the renal tubules. Smith's studies³¹ indicate that the renal tubules of normal man are capable of secreting about 52 mg of diodrast iodine per minute, those of women slightly less. Our average diodrast-T_m on a much smaller series of mixed subjects was 40 mg per minute.³²

Substances other than diodrast may, of course, be used for this purpose provided they are in part eliminated by tubular secretion. Figure

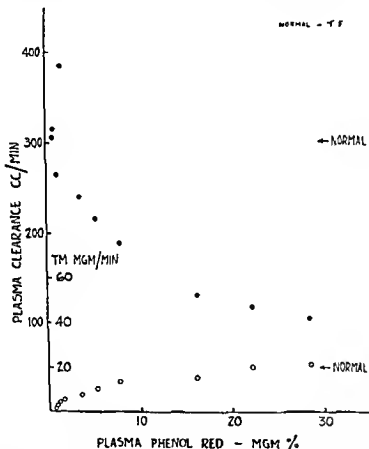


Fig 509—The relationship between plasma concentration, plasma clearance and tubular excretion of phenol red in a normal human subject

509 illustrates observations of a similar character in which phenol red was employed. As already stated, the kidney handles this substance with considerably less efficiency than it does diodrast or certain hippuric acid derivatives so that the absolute values are different, but the principle of estimating the functional capacity of the tubular excretory mass by measuring the maximal tubular output of the dye (phenol red T_m) is equally valid. For several reasons, the use of phenol red for these purposes is unwise and Smith's observations³¹

On purely mathematical grounds Lampport³⁴⁻³⁷ has derived formulas which suggest that change in the caliber of the afferent arterioles must also take place. Shannon³⁸ however, has pointed out that neither theory is entirely satisfactory.

INTERPRETATION IN THE PRESENCE OF DISEASE

The measurements of glomerular filtration rate, renal plasma flow and T_m appear to yield valid results in normal subjects but the presence of disease imposes certain limitations upon their unqualified acceptance. In Bright's disease particularly, it would seem more than likely that the distorted architecture of the kidney would also entail some perversion of function which might not only be undetectable by clearance methods but might even invalidate them. It must be remembered that clearance methods are over all procedures and can hardly be expected to reveal subtotal fluctuations in renal function. For example it is quite impossible to tell from a urea clearance of 50 per cent whether the patient has had one kidney removed or whether both kidneys are working at half their normal rates. Indeed some have felt³⁹ it hazardous to apply clearance methods at all to seriously diseased kidneys and even in anatomically normal kidneys certain extrarenal factors have been shown capable of profoundly modifying clearances. For example Heinbecker, Rolf and White⁴⁰ have produced marked changes in clearance and T_m values by interfering with the function of the anterior hypophysis, thyroid and adrenal cortex. Testosterone causes renal hypertrophy and an increased diodrast T_m .^{41, 42} Vitamin A increases urea and inulin clearances⁴³ and renal blood flow, glomerular filtration rate and diodrast T_m .⁴⁴ Hemorrhagic and traumatic shock^{45, 46, 47, 48, 49} and renal anoxemia^{50, 51} have been shown to produce discrepancies between actual renal blood flow and clearances of diodrast and *p*-aminohippurate because of impaired tubular extraction. These observations illustrate the fact that the mechanism whereby tubular cells move materials from the blood stream to the tubule lumen depends in part upon adequate supplies of hormones, vitamins and oxygen and that one cannot assume that this transport mechanism is of equal efficiency in all patients or even in all parts of the kidney parenchyma of a given patient. Reduction in tubular clearance may be affected as much by the impaired extraction as by reduction in blood flow.

It is not difficult to imagine many conditions in which tubular extraction capacity may be so diminished that plasma clearance falls far short of actual plasma flow. Sodium tartrate⁵², uranum⁵³ and carbon tetrachloride⁵⁴ have been shown to produce this effect and doubtless mercury does also. We³ felt that diminished tubular extraction of diodrast rather than reduction in renal plasma flow was responsible for the high filtration fraction shown by some of our

hypertensive patients, although there is much good evidence that the same relative figures may be achieved by efferent glomerular arteriolar constriction⁵⁵ Corcoran and Page⁵⁶ accept the plasma inulin clearance as a true measure of glomerular filtration rate and the plasma diodrast clearance as a true measure of renal plasma flow in chronic glomerulonephritis and malignant hypertension but say that "the equivalence of plasma diodrast clearance with effective renal plasma flow is invalid in conditions of widespread tubular renal injury." Although the relationships between urea and inulin clearances are usually well maintained in renal disease, they occasionally approach unity,⁵⁷⁻⁵⁹ a circumstance attributed to diminished urea reabsorption rather than to backward diffusion of inulin. It is apparent that in many instances of severe tubular damage the clearance of diodrast or hippurate may fail to give an even approximate index of renal blood flow.⁵⁹⁻⁶⁰

These criticisms have been recognized and apparently answered by Smith⁵⁹ who points out that clearances must be interpreted in relation to the mass of functioning tubular tissue. In Bright's disease the proportion of excretory to inert tissue progressively diminishes with the result that extraction ratios also decrease, but the ratio plasma clearance T_m still gives an indication of the amount of blood-perfusing, functioning renal tissue. The absolute clearances may then be untrustworthy in disease but they continue to have significance if considered in relation to the separate assays of tubular function.

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UNNECESSARY ABDOMINAL OPERATIONS FOR PATHOLOGIC LESIONS OF THE GENITOURINARY TRACT

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THE clinical manifestations of pathologic lesions originating in the genitourinary tract so closely mimic lesions of the intra abdominal viscera that unnecessary laparotomies with sacrifice of abdominal organs are done all too frequently. Cabot once stated that the most common operation for stones in the right ureter is appendectomy. It is not of rare occurrence to examine a patient who has had one or more abdominal operations for the relief of abdominal pain only to discover that a lesion of the kidneys or ureters has been the cause of the pain and the long unrelieved morbidity. Some patients have suffered for years from recurrent abdominal pain losing their ovaries and tubes, appendix or gallbladder and obtaining complete relief only after a ureteral stricture has been dilated or hydronephrosis or pyonephrosis has been adequately treated.

Dr. Edgar Burns of the Department of Urology of the Clinic has observed that over 40 per cent of the patients with anomalies of the genitourinary tract visiting the department have had abdominal operations not only without relief of symptoms but with definite progression of the urologic disease. A review of the literature reveals similar statistics regarding unnecessary abdominal operations for the relief of abdominal pain due to lesions confined to the urinary tract.

Kruse¹ writing on Hunner's ulcer, stated that half of his first eight patients had extravescical operations without relief. Wright² observed that in Hunner's series of ureteral stricture 30 per cent of the patients had abdominal scars from misapplied surgery. Brown and Wakefield³ reported two cases of patients with typical prolonged gallbladder symptoms in whom removal of the gallbladder gave no relief. Both patients had stones in the right kidney and obtained complete relief after their removal. Campbell⁴ reported 213 cases of abdominal pain in children with urologic disease. Fifty per cent of these had acute or subacute urinary infection of the latter cases fourteen were diagnosed as acute appendicitis and thirteen had previous appendectomies without relief. Caulk⁵ found that 27 per cent of his patients with renal or ureteral calculi or both had had appendectomies with

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out relief from pain. In Cecil's⁶ series of 300 cases of urologic lesions 28 per cent of the patients had stones in the kidney or ureter producing abdominal pain as the predominating symptom. 20 per cent of these had had abdominal operations without relief. Martin and Chynoweth⁷ in a review of 400 consecutive patients with urologic disease wrote that 50 per cent of the patients sent to the urologic department for cystoscopic data had come for some trouble other than that of the kidneys and that 50 per cent had more abdominal than genitourinary symptoms. They also stated that 25 per cent of cases of renal disease with abdominal symptoms are incorrectly diagnosed. Martin⁸ discussing hydronephrosis stated that when the lesion was on the right side the most common diagnoses were appendicitis, disease of the gallbladder or lesions of the tubes and ovaries and that following removal of these organs without relief the patients were then treated for such conditions as neurosis, lumbago, ptosis or indigestion. Massenburg⁹ reported a case of left pyohydronephrosis with abdominal pain in which appendectomy and later uterine suspension were done without relief. O'Neil¹⁰ reporting his cases of urologic disease at the Massachusetts General Hospital stated that 25 per cent of the patients with ureteral calculi operated upon for the stones had had previous operations for appendicitis or some other supposed intra-abdominal lesion without relief. Braasch¹¹ found that one third of his 143 patients with renal stones had had unnecessary laparotomies. He reported some very interesting findings in his series. Eighty-three of the patients had stones in the right kidney, fifty-five in the left kidney and five in both kidneys. There were twenty-three patients with stones in the left kidney who had had either appendectomies or cholecystectomies without relief of symptoms. In Cabot's¹² 157 cases of stones in the kidneys or ureters or both, twenty-six had the following unnecessary laparotomies without relief: appendectomy, ten; exploratory laparotomy, seven; fixation of the kidney, four; operations for gallbladder disease, one; and decapsulation of the kidney, salpingo-oophorectomy, suprapubic cystotomy and removal of adhesions, one each.

From this brief review it can readily be seen that 25 to 30 per cent of patients with pathologic lesions of the kidneys, ureters or both have had previous laparotomies for nonexistent lesions of the abdominal viscera. A large number of these improperly treated patients have been attended by the average surgeon who specializes in general surgery but also does general practice. The percentage cited is undoubtedly low; it probably would reach 35 to 40 per cent as a general average.

That urologic disease constantly manifests itself clinically as an acute or chronic abdominal lesion has been reported by many authors. Atherton¹³ reported a case of a urologic lesion of the upper urinary

tract producing pain in the upper right quadrant of the abdomen simulating gallbladder disease. Brown and Wakefield³ reported several cases of renal stones in which the clinical symptoms suggested disease of the gallbladder and removal of the gallbladder gave no relief. In this same paper they discussed the "enterorenal syndrome of Mayo," which is a condition seen in elderly patients who have signs and symptoms of intestinal obstruction, accompanied by an elevation in the blood urea nitrogen content and a decreased urinary output. They reported two cases, in both of which recovery ensued, in one instance following conservative treatment and in the other after exploration. Campbell⁴ believed that the urologic lesions which cause abdominal symptoms are predominately obstructive in character and that grave urologic lesions with abdominal pain may exist despite the presence of normal urine. This certainly adds confusion to the accurate diagnosis of urologic diseases.

In Cecil's⁵ 300 cases of lesions in the upper urinary tract there were a large number in which the pain was limited to the abdomen. Twenty eight per cent of the cases with stones in the kidney and ureter had abdominal pain without pain in the back. In 26 cases with typical back pain referable to the kidney, pain was also referred to the abdomen, in two of these cases the abdominal pain was diffuse. In forty cases of tuberculosis of the kidneys there were seven cases with no pain in the back, the pain being limited to the abdomen. Cecil listed the percentage of urologic lesions that presented clinical symptoms of abdominal disease without back pain as follows: stones in the kidney and ureter, 28 per cent, renal tuberculosis, 17.5 per cent, pyelonephritis, 5.5 per cent, hydronephrosis, 15 per cent, and tumor of the kidney, 50 per cent (small series). The most common site of referred pain was the gallbladder and appendix. Stone, according to Braunsch¹⁴ reported 251 urologic cases in which pain and tenderness in the kidney region was present in only 117. In twenty six cases pain was abdominal and generalized. Pain was referred to the gallbladder in thirty cases, to the lower abdomen in thirty two cases, to both sides of the abdomen in fifty six cases, to the affected side of the abdomen in forty cases, and to the contralateral side of the abdomen in sixteen cases. Squires and Bateman¹⁵ described a "retroperitoneal syndrome" from reflex action of the gastrointestinal tract from stimuli arising in the kidney and passing through the celiac plexus. In ninety eight cases of this syndrome they found 50 per cent with gastrointestinal symptoms and 25 per cent with no symptoms of renal disease. Martin and Chynoweth⁷ found that in 400 urologic cases only 30 per cent presented the classical urologic symptoms. Peacock and Hun¹⁶ in a study of seventy six cases of ureteral stricture stated that 29 per cent of the patients had a dull pain in the abdomen simulating abdominal disease.

Why should a pathologic lesion of the genitourinary tract manifest itself without symptoms pertaining directly to the lesion but with reflex symptoms which are entirely abdominal in character? The chief symptom in both intra abdominal lesions and urologic diseases is pain. This pain is due primarily to involvement of either the somatic or sympathetic nervous systems or both and secondarily to involvement of contiguous organs or structures. The viscera in both the abdomen and the genitourinary tract are either solid or hollow. The hollow viscera are composed almost entirely of neuromuscular tubes whose function is secretory, absorptive and excretory. The solid viscera also have the same function. They not infrequently contain within their parenchyma tubes lined with epithelium. The gross difference between the two is that the solid viscera are encased in a comparatively unyielding fibrous capsule whereas the hollow viscera are elastic and yield to increases of pressure. Both the solid and hollow viscera are supplied by similar nerves and have similar blood supply and lymphatic drainage. Therefore, they are closely if not intimately associated with each other. The sympathetic nerve supply to both the genitourinary tract and abdominal viscera has a common dispatcher or intergrating point, the celiac ganglion and celiac plexus. The latter is a composite of the splanchnic and associated plexuses. Thus pain from lesions in the genitourinary tract and the abdominal viscera may be widespread and irregular because of intimate integration of both the somatic and sympathetic receptive fibers. The pain originating from the kidneys and abdominal viscera is referred to the tenth, eleventh and twelfth dorsal and the first lumbar spinal segments.¹¹ The stimuli again may be distributed up and down the spinal cord to many segments before being relayed to the brain. Another source of stimuli is that the kidneys and ureters are in close association anatomically with the parietal peritoneum (with its sensory nerve supply) the hepatic and splenic plexuses of the colon, the duodenum and the ileohypogastric, ileo inguinal and lateral cutaneous femoral nerves. That the symptoms of both the abdominal and urologic viscera can mimic each other is understandable from this cursory description of the anatomy and associated anatomic relationships with other important organs and structures.

It would appear that the mechanism of production of pain in the urologic tract is similar or identical to that in the abdominal cavity. Pain is produced primarily by obstruction which may be acute or chronic in character. Obstruction of the ureter if sudden not only causes dilation of the ureter but also of the distensible components of the kidney. Since the ureter as well as the gastrointestinal tract is endowed with peristaltic activity, the pain produced by obstruction to the lumen of each is characteristically intermittent or colicky. If the obstructing process is gradual the pain is more of a dull type.

which also may or may not be intermittent. The character of the pain and its clinical manifestations may vary from time to time depending upon the intensity of the dilation of both ureters and kidneys and even the bladder. Acute obstructions of the urologic tract may be due to either infection or renal or ureteral stones, or both. Chronic obstruction is produced by either stones or stricture or both associated with subacute or chronic infection. In the solid viscera the pain is produced, in the majority of instances, by infection of the parenchyma and tubular components or new growths which distend the unyielding fibrous capsule, and the pressure is secondarily offered to the arteries, veins and nerves producing somewhat of a vicious cycle. The character of the pain is dull and more or less continuous. However, acute distention of the parenchyma will in turn produce acute pain, which is continuous, whereas that of the hollow viscera (ureters, small and large bowel and biliary ducts) is intermittent. Therefore, pain from lesions of the kidney or ureter at the pelvic junction is not infrequently referred to the right upper quadrant of the abdomen, simulating the pain of acute pathologic processes of the gallbladder and ducts or ruptured peptic ulcer. On the other hand, if the lesion is low in the ureter or bladder, the pain may be referred to the appendix, sigmoid or female generative organs. Pain from lesions of the seminal vesicles may also be referred to the appendix or sigmoid. The slowly progressive lesions occurring in the upper or lower portions of the urinary tract produce symptoms referable to the abdomen simulating diseases of the abdomen, i.e., gallbladder, pancreas, appendix, sigmoid and female adnexa. The signs and symptoms common to acute lesions of both the abdominal and urologic viscera are pain, anorexia, nausea and vomiting, abdominal rigidity, distention, fever and leukocytosis; in chronic lesions they are pain, anorexia, distention, loss of weight and anemia.

According to Connell,¹⁵ the renal lesions which are likely to be confused with intra-abdominal lesions are renal or ureteral stones, Dietl's crisis, unilateral hematogenous infection, uremia, perinephric abscess and pyelonephritis. Braasch¹⁶ stated that in his 251 cases of kidney stone, only 117 had typical pain and tenderness in the kidney region; general abdominal pain was present in twenty-six cases, pain was referred to the gallbladder in thirty cases, to the lower abdomen in thirty-two cases, to both sides of the abdomen in forty cases and to the unaffected side of the abdomen in sixteen cases.

In Campbell's* series of 213 cases, over 50 per cent had an acute or subacute urinary infection that was suspected at once or after an early examination. However, he pointed out that grave urologic lesions may be present despite the evidence of normal urine. He also

* Campbell¹ has given an excellent classification of the lesions of the genitourinary tract which may produce abdominal symptoms.

suggested that in patients with lower abdominal pain, the presence of vesical residual urine should be determined

According to Eisendrath¹⁹ the urologic lesions that mimic appendicitis or upper abdominal diseases are (1) acute blocking of the outlet of the renal pelvis or upper ureter, (2) kinking of the ureter and torsion of the renal pedicle, (3) acute occlusion of the outlet of the renal pelvis or upper ureter by an anomalous vessel crossing the ureter and (4) acute infection of the kidney or its surrounding fat with or without stones. Those that simulate appendicitis are (1) ureteral calculi in the iliac or pelvic portion, (2) ureteral strictures in the iliac or pelvic portion, (3) ureteral kinks (abnormal renal mobility), (4) chronic nephritis of the painful type (nephritis dolorosa), (5) passage of uric acid or oxalate or calcium crystals, (6) tubercle ureteral and renal crises, (7) ureteritis (usually associated with pyelonephritis) and (8) seminal vesiculitis with secondary involvement of the ureteral wall. Lesions imitating symptoms of abdominal tumors are (1) iliac renal ectopia, (2) pelvic renal ectopia, (3) crossed (fused) ectopia, (4) horseshoe kidney and (5) unilateral double kidney. Hertzler,²⁰ writing on acute localized infection of the kidney, stated that the pain may be abdominal and simulate appendicitis, gallbladder disease or perforation of a peptic ulcer of the duodenum or stomach. He also stated that the urine may show few or no changes.

Jablons²¹ in discussing the retroperitoneal syndrome stated that the innervation of the gastrointestinal tract arises from the same centers as that of the kidney and ureter and that the gastrointestinal tract is supplied by the vagus nerve, celiac plexus and sympathetic fibers which traverse the greater and lesser splanchnics. In the celiac plexus reflexes are set up by impulses originating in the kidney, ureter or posterior parietal peritoneum. This explains the reflex abdominal symptoms from urologic lesions because the urologic symptom complex is submerged by the predominant abdominal signs and symptoms.

Squires and Bateman¹⁶ reported ninety-eight cases of renal disease. 50 per cent of the patients had gastrointestinal symptoms and 25 per cent had no symptoms of renal disease. The gastrointestinal manifestations were nausea, vomiting, pain, abdominal distention, belching, heartburn, epigastric distress, constipation or diarrhea. In twenty-two cases of pyelonephritis terminating in uremia, sixteen had abdominal symptoms, i. e. pain, nausea and vomiting.²² Enlargement of the liver, hematemesis and melenæ were only occasionally present.

In the short review given in the preceding paragraphs it is apparent that almost any disease of the urologic tract from the kidney and perirenal tissues to the bladder, prostate and seminal vesicles can mimic any one of the various pathologic diseased states occurring

within the abdomen. This becomes increasingly true when the signs and symptoms are lacking in urologic disorders.^{4 6 7 20 21 23 24 25}

It therefore becomes of paramount importance to make an accurate differential diagnosis if unnecessary operations are to be prevented. In the majority of instances an accurate diagnosis of urologic disease can be made provided one constantly keeps in mind the abdominal mimicry of genitourinary disease, takes a most careful history and does a complete physical examination. Carefully selected diagnostic laboratory procedures should be included to establish the diagnosis.

It is impossible and not desirable to give the clinical manifestations and differential diagnosis of each pathologic lesion of the genitourinary tract, but the causative factors and their delimitations and the methods that will aid in the diagnosis will be discussed. The urologic problems can be divided into two main groups—the acute and chronic, the latter being responsible for the greater number of mistakes. The acute conditions are due mainly to infection produced by both the coecal and bacillary groups of organisms. In acute infections, the parenchyma, the renal pelvis or both may be involved. The infection may be superimposed on a preexisting lesion such as hydro-nephrosis, chronic pyonephrosis with or without stones, or septic infarcts of Brewer. The perirenal tissues may be involved by ruptured pyonephrosis, cortical suppuration or perinephritic abscess. Acute infections of the ureters, either ascending or descending with or without stones, may be secondary to acute infections of the bladder, kidneys or periureteral lymphatics.

The noninfectious lesions producing acute symptoms are primarily the result of a sudden block of the renal pelvic outlet or ureters. The obstruction may be due to stones, anomalous arteries (upper pole arteries, 4 per cent, lower pole arteries, 3 per cent²⁶), ureteral strictures or ectopic kidneys.

The symptoms of acute lesions of the genitourinary tract are characterized by sudden onset. There may or may not be chills, the fever is higher than that seen in abdominal lesions and the pulse rate is lower. The white cell count is higher and more stable in urologic than in abdominal disease unless the latter is associated with complications. Nausea and vomiting are less common in acute renal lesions than in intra abdominal lesions. Muscle spasm, when present, is of greater diagnostic importance than is pain or tenderness.⁶ Moderate to severe ileus may or may not be associated with acute infections, as a rule, it is more common in the acute nonbacterial lesions. In acute disease of the infectious or noninfectious type pain is due to obstruction (renal or ureteral) of the outflow of urine. In the nonbacterial form the predominating symptom is pain, with little or no systemic reaction. In both, the pain may be of an intermittent or colicky type. In cases of infection the urine will, in all probability, reveal the presence of

pus and bacteria. However, in cases in which the ureter is blocked the infected material cannot be passed, therefore, the urine may appear normal on microscopic examination. According to Campbell,⁴ in over 50 per cent of his cases of acute or subacute urinary infections the character of the lesion was suspected at once or after an early examination. In the nonbacterial acute lesions the urine may be without pathologic significance.

The laboratory investigations that will aid in diagnosis and prevent unnecessary abdominal operations are roentgenography, including excretory pyelograms, retrograde pyelograms, and cholecystograms, gastrointestinal studies, and thorough cystoscopic examinations. Gastrointestinal studies and cholecystograms are more useful in the chronic than in the acute urologic lesions with abdominal symptoms.

The roentgenogram will reveal stones in the urologic tract, enlarged kidneys and obscuration or obliteration of the lateral border of the psoas muscle. The most important findings revealed by excretory pyelograms pertain to kidney function, stones and distortion or block of the pelvis or ureters. The excretory pyelogram is by far the simplest, most rapid and most useful test in determining urologic disease although it may sometimes be necessary to supplement it by cystoscopic examination and retrograde pyelographic studies. Nevertheless, even in very acute urologic or abdominal disease the excretory pyelogram can, in a few minutes, give aids in diagnosis that would eliminate unnecessary operations. In fact, I am so convinced of its diagnostic value that I not only believe but recommend that it should be a routine procedure in all patients forty years or more of age. The almost routine use of excretory pyelographic studies in both the army and urologic clinics has demonstrated a high incidence of anomalies of the urologic tract which in the past have been overlooked. In cases in which acute ileus is secondary to urologic disease and simulates intestinal obstruction, the roentgenogram is of definite value in differential diagnosis. In acute ileus associated with genitourinary disease, gas can be seen in both the distended small and large bowels, whereas in ileus originating in the gastrointestinal tract, gas is present only in the small bowel. Gas and fluid levels are more commonly associated with ileus arising in the intestinal tract.

According to Eisendrath¹⁸ the most common abdominal diagnosis in the case of urologic lesions is appendicitis. The appendix is erroneously removed in from 10 to 30 per cent of cases. The gall

to remove as the lumbar sympathetics, herniated disk, or the bladder, the frequency of error would be practically nil.

CONCLUSIONS

In reviewing the literature on the abdominal manifestations of urologic lesions, an attempt has been made to explain the peculiar symptomatology upon an anatomic and neurophysiologic basis. The interrelationship of the somatic and sympathetic nerve supply of both the urologic and the gastrointestinal tracts explains the abdominal reflex symptoms from urologic disease. It should be remembered that when there exist both urologic and abdominal symptoms the latter not infrequently overshadow the former. In from 30 to 40 per cent of cases of urologic disease the signs and symptoms are abdominal and not genitourinary and less than 50 per cent of patients with urologic lesions exhibit classical genitourinary symptoms. The abdominal symptoms of acute and chronic urologic lesions so closely mimic abdominal disease that from 20 to 30 per cent of patients with urologic conditions have had previous laparotomies not only without relief but with progression of the urologic lesion.

Every patient with abdominal symptoms and urologic manifestations however slight must be thoroughly evaluated by both the surgeon and the urologist before abdominal section is advised. Patients with indefinite abdominal pain should have a thorough urologic survey before the appendix, female adnexa or gallbladder is removed. The laboratory and roentgenographic studies (including excretory pyelograms) will give inestimable information which will prevent unnecessary removal of nonoffending abdominal organs. A complete laboratory study of the urine in all suspected or unsuspected urologic diseases will reveal sufficient pathologic states to warrant complete urologic surveys. The high incidence of unnecessary abdominal operations for urologic lesions can be reduced or almost completely eliminated only by constantly keeping in mind those lesions of the genitourinary tract which closely or completely mimic acute or chronic lesions of the intra-abdominal organs.

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THE PATHOLOGY OF GENITOURINARY NEOPLASMS

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To understand the nature of tumors it is important to know their characteristic gross and microscopic appearance, to recognize the various anatomic complications produced by them, and to be familiar with a few of the theoretical considerations which recur in scientific discussions regarding them. This discussion is concerned primarily with tumors of the kidney, renal pelvis, ureter, urinary bladder and prostate gland. Carcinoma of the prostate gland is the only genital tumor included in this communication.

KIDNEY

The commonest and most interesting tumor of the renal parenchyma is the malignant growth derived from renal epithelium and best known by the name *hypernephroma*. It occurs predominantly in men over 45 years of age. The hypernephroma is interesting because it is grossly and microscopically distinctive, because, although it commonly follows a stereotyped clinical pattern, symptoms from metastatic growths may be dramatic and bizarre, and finally, because it has been the subject of an academic controversy for a number of years.

Grossly, the hypernephroma may involve the kidney at either pole or at any point between the two poles with no apparent predilection for any one site. It bulges into the capsule and often into the renal pelvis as a result of which the classical symptom of painless hematuria is produced, less commonly, it may involve the renal vein. The latter anatomic complication of renal tumors is important because, as shown by McDonald,¹ involvement of the renal vein increases the gravity of the prognosis. Tillisch and co-workers² have reported cases in which the tumorous thrombus extended from the renal vein into the inferior vena cava and heart. It is possible that many of the bizarre metastatic tumors originating from hypernephromas are the result of invasion of the renal vein and subsequent hematogenous spread of the growth. Among the unusual forms of metastasis are those often located in bones. These may give rise to mitral symptoms caused by the secondary growth such as pathologic fracture when the primary tumor in the kidney has remained clinically silent. Such cases may not be com-

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mon but they are sufficiently dramatic so that probably a disproportionate number have been recorded.

The gross picture occurs in more scirrhous papillary hypernephroma. One of these is the tumor which contains less lipid and is consequently not as yellow, and the other is a papillary



Fig. 511—Hypernephroma of lower pole. Involvement of a medium sized renal vein is apparent on the left.

erous cystic tumor which often contains appreciable deposits of calcium salts. The latter lesion seems to be a slow growing or low grade hypernephroma but is given an especial designation such as papillary adenoma by some authorities. Higgins³ has reported a group of such adenomas.

Microscopically, the usual picture in hypernephroma is that of clear cells in papillary or alveolar arrangement invested by a delicate reticular lacework of stroma. The clearness of the cells has not been adequately explained because it is apparent that lipid accumulations alone do not account for this peculiarity. Fite⁴ has called attention to

glycogen deposits in these cells and it is probable that this observation will prove helpful in explaining the clear cells. Less characteristically, the cells may contain a brownish pigment.

Variations in the degree of anaplasia of hypernephroma cells have been observed by Hand and Broders,⁵ who classified 193 cases of hypernephroma into Broders' four grades of malignancy; they found that, as the degree of anaplasia increased, the prognosis became poorer. In their series, 50 per cent of the tumors were of grade I or II malignancy, the slower growing varieties. This is somewhat surprising in view of the common impression that the hypernephroma is an especially "wild" tumor, and it is apparent that in some cases the dramatically malignant aspects of the tumor have been overemphasized.

Other variations in the standard microscopic picture just described are seen when the cells are not clear—the dark cell type. The darker cells seem to occur perversely without good reason irrespective of the degree of anaplasia of the tumor. Another variation is that the tumor may be polymorphous. It may resemble the sarcoma in some areas, the angioma in others and the typical hypernephroma in still other regions. In fact, the polymorphous character of hypernephromas is so outstanding that some authorities list the variations of form that may be present in a single tumor as one of the characteristics of this specific form of neoplasm.

The hypernephroma was named by Grawitz,⁶ who conceived the name because he postulated that the tumor was derived from cell rests of adrenal gland tissue in the kidney. He was soon opposed by Stoerck,⁷ who insisted that the tumor was derived from renal rather than adrenal cells. Stoerck⁷ and Wilson⁸ who, among others, translated the controversy into the American literature, disproved most of Grawitz's contentions and although Grawitz still has a few distinguished supporters, the majority of authorities now concede that this characteristic tumor of the kidney is derived from renal cells rather than from adrenal rests as Grawitz supposed.

Those who adhere to the renal cell origin of this tumor are placed at a disadvantage by the tenacity of the name "hypernephroma," which has established itself in spite of the best anatomic evidence that the prefix "hyper," which implies adrenal origin, is a misnomer. Those who have attempted to substitute other designations such as adenocarcinoma of the kidney, nephroma, malignant nephroma or renal cell carcinoma are eventually compelled to explain that the name used really means the "so called hypernephroma." A simple, if not logical, solution would be to retain, without explanation or apology, the term hypernephroma as a distinctive name for a distinctive tumor and discard the Grawitz theory of origin from adrenal rests.

It is evident that pathologists are loathe to abandon the Grawitz

theory entirely because from time to time there is recorded an occasional case of renal tumor which, because of its close resemblance to adrenal cortical tissue, is said to be a "true" hypernephroma derived from adrenal rests as distinguished from the ordinary hypernephroma derived from renal tissue. Higgins,² for instance, recorded an endocrine effect, notably hypertension evidently produced by one of the six cases of adenoma which he reported, and Mitchell and Angrist¹⁰ described cases in which there was anatomic evidence of derivation of hypernephromas from adrenal rests.

This ancient controversy might be summarized by stating that the remaining points in favor of the Grawitz theory are (1) a tenacious name, (2) the presence of lipid in the cells of both the hypernephroma and the adrenal cortex, and (3) the fact that adrenal rests do occur in the kidney. The weakest features of the Grawitz theory are the facts that (1) even those tumors which most closely resemble adrenal cortex anatomically have not produced endocrine disturbances except possibly the case reported by Higgins, and (2) hypernephromas resemble small adenomas of the renal cortex more closely than they do adrenal rests. It is evident that adenomas of this type are derived from renal cells and that hypernephromas are derived from adenomas, because as Bell¹¹ and Trinkle¹² have stated, any sharp line of division of renal tumors into adenoma on the one hand and hypernephroma on the other is purely arbitrary since the relationship is close.

The two benign lesions of the kidney, adenoma and adrenal rests have been mentioned so often in the discussion of hypernephroma that a description of these smaller and less significant nodules seems pertinent. The *adenoma* can be found only when the capsule of the kidney is stripped and the cortex searched for suspicious yellow nodules which may vary in size from a pin point up to 4 cm. in diameter. All those over 4 cm. in diameter are arbitrarily designated as hypernephroma. Most of those encountered are less than 0.5 cm. in diameter. The cortex must be scrutinized carefully and suspicious yellow nodules sectioned. Usually the adenoma is found on the surface, but occasionally one that has not reached the surface may be found on section. This latter type may resemble an abscess except that the contents are solid.

Microscopically, the adenoma is usually papillary and of dark cell rather than clear cell type. Deposits of calcium salts are common and are said to indicate slow growth. The cells and especially the nuclei are small and uniform in character. Less commonly, the adenoma is of the clear cell type. The tumor is usually found adjacent to normal renal parenchyma with

little or no capsule interposed. The golden yellow color of these tumors seen grossly is not easily explained on the basis of the microscopic appearance because it is difficult to demonstrate lipoid in these tumors but lipoid material similar to that found in hypernephromas has been demonstrated in some adenomas and it is probable that the yellow color is due to lipoid content.

If a careful search is made for adenomas they can be found in about 10 per cent of kidneys in adults. Trinkle¹² thought that they occurred more commonly in scars and in scarred kidneys than in normal kidneys. It is apparent that adenomas like hypernephromas are found more commonly as age advances.

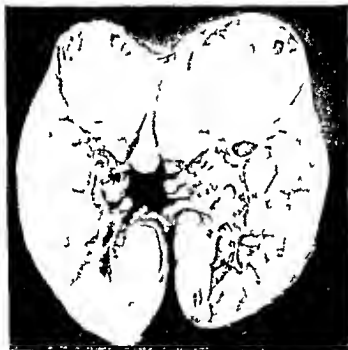


Fig 512.—Wilms tumor. This tumor was bilateral and the major involvement was on the opposite side.

The presence of *adrenal rests* in the kidney and along the structures which lead from the adrenals to the gonads is explained by the embryologic origin of the adrenals, kidneys and gonads from the mesoderm of the mesonephric ridge. It is apparent that bits of adrenal cortical tissue may be carried downward by migration of the gonads or may develop as adrenal tissue on the surface of the kidney. Such bits of adrenal tissue or rests are rarely observed in association with the gonads and are usually discovered by chance.

Adrenal rests in the kidney occur as small plaques of adrenal cortical tissue on the superior pole and may be found as bright yellow or orange spots after the capsule has been stripped. The incidence of

adrenal rests seems to be the same for children as for adults and has been variously given as from 1 to 3 per cent. Microscopically the rest is composed entirely of adrenal cortical tissue and is so intimately associated with the renal substance that an occasional renal tubule may be noted in the center of the adrenal cell mass. The cell rest does not contain tissue of the adrenal medulla. Occasionally the entire adrenal gland may be attached to the superior pole of the kidney. This latter anomaly is called heterotopia.

Wilms tumor of the kidney is less common than the hypernephroma. In the 117 cases of malignant tumor of the kidney reported by Bixler and his associates¹³ there were ninety-four cases of carcinoma of the cortex and thirteen cases of Wilms tumor. According to Weisel, Dockerty and Priestley¹⁴ 20.4 per cent of all malignant tumors occurring in children are Wilms tumors. Although this neoplasm is probably the commonest single variety of malignant tumor found in children it occasionally occurs in adults. In Weisel's series of forty-four chiefly surgical cases none of the Wilms tumors were bilateral although bilateral Wilms tumors have been reported at necropsy. An example of bilateral Wilms tumor encountered at necropsy is illustrated in Figure 512. In this case a large tumor appeared in the left kidney and the photograph shows the tumor in the right kidney which was removed at necropsy.

Grossly Wilms tumor is homogeneous white or pink and encephaloid. Areas of hemorrhage and necrosis occur. The tumor grows rapidly and may metastasize readily. Microscopically the most characteristic cell is a mesodermal fibroblast which may differentiate into renal tubules or glandular structures. The cellular tumor composed of mesenchymal cells and glands is characteristic and closely resembles the structure of the outer edges of the renal cortex in the human fetus prior to the seventh month of gestation. In some Wilms tumors there are striated muscle fibers and other mesodermal elements. These latter elements are most easily seen microscopically when the Wilms tumor has been treated preoperatively with roentgen therapy. Under such circumstances the roentgen rays destroy most of the essential mesodermal cells of the tumor and leave a residuum of the other better differentiated tissues.

It is generally supposed that the Wilms tumor does not have a benign tumor in close relationship to it such as the relationship which the adenoma bears to hypernephroma, but there is a curious small fibrous tumor occurring in the kidney which is a mixture of well differentiated mesodermal elements. There is no evidence to suggest that the fibroma of the cortex of the kidney is a slowly growing or early Wilms tumor but the presence of multiple tissues of mesodermal origin indicates that the fibroma is distantly related to the Wilms tumor.

Grossly, the *fibroma of the cortex* is a tiny, white lesion encountered when the capsule of the kidney is stripped. Part of the tumor adheres to the capsule but the greater part remains in the cortex of the kidney (Fig. 513). Microscopically, this tumor is composed chiefly of the adult type of collagenous fibrous tissue but it also contains occasional renal tubules, smooth muscle cells, adipose tissue and perhaps other mesodermal elements, all completely differentiated. It evidently has no clinical importance.

Other benign tumors of the renal parenchyma occur. *Lipomas* are not common. *Fibromas*, often myxoid in character, are occasionally encountered in the pyramids of the renal medulla. According to Bell,¹¹



Fig. 513—Capsular fibroma. Three fibromas are present but only one is clearly illustrated.

these are probably not true neoplasms. They never exceed 1 cm. in diameter and apparently never become malignant.

Hemangiomas of the kidney may produce hematuria assumed to be "essential" because of normal urograms. Cases have been reported by Rives and Pool¹⁵ and Rottino and Mohan.¹⁶ Bell has reported that one such case occurred in 30,000 necropsies in his experience.

Sarcomas of different varieties occur rarely in the kidney. A convenient reference is Rademaker¹⁷ who has reviewed the literature.

It is possible that an especial form of *carcinoma of the kidney* with its origin in the tubules of the renal medulla may occur. Small alveolar neoplasms which do not fit ordinary classifications of renal tumors

occur rarely in the region of the hilus of the renal parenchyma. Since the collecting tubules of the medulla have a different embryologic origin from the tubules of the cortex, it is probable that a distinctive tumor derived from the collecting tubules will eventually be discovered if it has not already been described.

RENAL PELVIS

Papillary transitional cell carcinomas of the renal pelvis are embryologically and morphologically related to tumors of the bladder. They may be warty, papillary tumors or they may be more sessile and infiltrating. McDonald and Priestley¹⁸ have reported seventy-five cases



Fig. 514. Papillary carcinoma of renal pelvis. Spread down the ureter is apparent.

in which they noted that the prognosis is influenced by the degree of anaplasia of the tumor and by whether or not the renal vein is involved.

It is known that papillary tumors of the urinary tract may spread down the ureter into the bladder and even into the urethra, but the process by which this spread takes place is not clearly understood. McDonald suggests implantation, lymphatic spread, and carcinogenic irritation of the urinary epithelium as three possibilities. Melcous¹⁹ also suggests the possibility that a disease of uroepithelium vulnerable to a carcinogenic agent may be a factor in the seeding of papillary growths along the urinary tract. Figure 514 illustrates the appearance

of shaggy papillary tumors of the renal pelvis extending down into the ureter. It is essential that urologists understand this type of spread so that they will investigate the entire urinary tract if a papillary tumor is found in some portion of it. It is also essential to understand this principle of spread if operations on the kidney are going to be sufficiently radical to include ureterectomy with nephrectomy in cases of carcinoma of the renal pelvis.

URETER

Primary tumors of the ureter have been reported recently by Barnes and Kawachi,¹⁰ Kraus¹¹ and McMahon.²² Recently interest in endometriosis involving the urinary tract has increased. Recent references are O'Connor and Greenhill,²³ Goodall,²⁴ Kretschmer² and Marshall.¹⁰

URINARY BLADDER

Carcinomas of the urinary bladder occur predominantly in elderly men and are more common than carcinomas of the kidney and ureter. The pathologic picture of papillary carcinoma of the urinary tract is the same as that of the pelvis, ureter or bladder. Grossly, these lesions are composed of tentacle-like masses of papillary tumor. In the bladder there seems to be no tendency toward retrograde spread of the papillary growth and urethral implants do not seem to occur but multiple carcinomas of the bladder mucosa may occur and it is apparent that secondary tumors may appear on the portion of the mucosa which contracts the tumor when the bladder is collapsed—the "kissing cancer." Microscopically, the tumor is composed of transitional epithelium which surrounds a thin central core of connective tissue containing a capillary.

In the lowest grade papillary carcinoma the transitional epithelium of the papillary projection closely resembles the transitional epithelium of the bladder and may differ chiefly in that it seems more robust and less easily desquamated by handling than the normal. In the grade II papillary carcinoma, the epithelium is thicker and the cells are more pleomorphic. The papillary character of the grade III papillary carcinoma is less apparent and the pleomorphism and irregular polarity of cells are more striking. This tumor is nearly always infiltrating as well as papillary. In the grade IV carcinoma monster nuclear forms are present and pleomorphism of cells is extreme. Some remnant of the papillary character of the tumor may persist but this is not a prominent feature of the tumor. The nucleoli are large and stand out clearly in vesicular nuclei in the higher grade tumors. The notorious complication of lower grade transitional cell carcinomas is recurrence. Higher grade tumors metastasize readily, lower grades less readily.

Squamous cell carcinoma of the urinary tract differs from transitional cell carcinoma in that the former are keratinizing tumors and form keratin pearls like the ordinary squamous cell carcinoma of the lip. Grossly, this tumor is usually a crater-like ulcer and is infiltrating; it metastasizes but does not appear to implant. The squamous cell carcinoma of the urinary tract is supposed to arise from areas of leukoplakia or keratinizing metaplastic epithelium which in turn is known to be associated with urolithiasis or other chronic inflammatory disease. The actual association of squamous cell carcinoma with leukoplakia in the mucous membranes of the mouth is well known, but the association of squamous cell carcinoma of the bladder or renal pelvis with leukoplakia in these regions is more difficult to demonstrate. However, the assumption of their association is reasonable in view of the microscopic morphologic picture of the two keratinizing lesions.

Among malignant tumors of the bladder, there occur *unusual tumors* that do not fit readily into ordinary classifications. An example of such a tumor is one of primary osteogenic sarcoma reported by Tremblay, Crane and Harris,²⁷ and another, apparently a carcinoma associated with sarcoma arising from the pelvic bones, reported by Shoemaker and Robertson.²⁸ Colloid (mucoid or gelatinous) carcinomas may be primary in the urinary bladder, and, when they occur, they are found in the dome. This location is significant because colloid carcinomas occur in the urachus and it has been assumed that colloid carcinomas of the dome of the bladder have their origin from the site of attachment of the urachus.²⁹

PROSTATE

Carcinoma of the prostate is a relatively common disease of the elderly. Grossly, it is characteristically stony hard and yellow in color but actually it is rather difficult to distinguish carcinoma of the prostate grossly except in the more obvious cases and it has never been possible to make a diagnosis from gross inspection of surgical material with any degree of certainty. Clinical impressions obtained by rectal palpation of the gland seem to be more consistently accurate than impressions gained by gross pathologic examination.

Microscopically, the diagnosis of carcinoma of the prostate is not entirely easy because of a number of confusing factors. There may be proliferation of the epithelium around the urethra and that lining the prostatic ducts around the urethra which is actually benign but requires some experience and care to distinguish from carcinoma. Distortion of prostatic acini by compression of contiguous cysts or by inflammatory reactions must be interpreted with care. On the other hand, the alterations in carcinoma produced by orchiectomy and stilbestrol are not completely understood so that the pathologist must live in some fear of missing, after such therapy, a carcinomatous growth.

which may have been obvious on a previous examination. None of the established criteria for the diagnosis of malignancy ever seems to help in a questionable case, neural involvement is rarely seen, and the cells of prostatic carcinoma are so small that the ordinary nuclear and nucleolar changes characteristic of many varieties of carcinoma do not appear in carcinoma of the prostate. Finally, since prostatic malignancy commonly begins in the posterior part of the gland and the tissue removed by surgical operation is taken from around the urethra, the pathologist might be unable to demonstrate carcinoma in a case in which the clinical diagnosis has been established by palpation of the posterior portion of the gland.

In spite of all these difficulties there is a reasonable correlation between pathologic diagnosis, clinical impressions and follow up observations. Microscopically, the average carcinoma of the prostate is characterized by small glands lined with small cuboidal cells in which the nuclei have lost their polarity. This is a most important distinction because in the normal or hyperplastic prostate, the cells are tall columnar and the nuclei are arranged regularly along the basement membrane with their long axes perpendicular to it. The carcinomatous glands infiltrate the smooth muscle and fibrous stroma of the prostate in such a way that the stroma is crowded and thinned. Most cases of carcinoma of the prostate are graded II. Some are lower grade, the glands in grade I carcinomas are larger but there is no real difficulty in distinguishing these from the normal because of hyperchromatism of the carcinomatous glands. The more anaplastic carcinomas are not difficult to diagnose because of diffuse infiltration by small, poorly formed glands and more evident pleomorphism of nuclei.

SUMMARY

The gross and microscopic picture of the benign and malignant tumors of the kidney, renal pelvis, urinary bladder, and prostate gland have been discussed. Some theoretic considerations concerning the origin of these tumors and the possible relationships between certain of the benign and malignant tumors have been reviewed. References are given to some of the less common lesions that involve these organs.

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THE MANAGEMENT OF BLADDER NECK OBSTRUCTION

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THERE are many entities which, although differing in their pathologic appearance, occlude the vesical neck, produce the same symptoms and eventually cause identical changes in the bladder and upper urinary tract. The principal causes of bladder neck obstruction in adults are benign prostatic hypertrophy, carcinoma of the prostate, contracture of the vesical neck or median bar and acute prostatitis. In children the condition is produced by congenital valves of the posterior urethra, congenital hypertrophy of the verumontanum and congenital contracture of the vesical neck. In addition to the management of bladder neck obstruction due to these conditions the newer concept of the treatment of the neurogenic bladder in both sexes based on obstruction will be discussed.

ETIOLOGY

Benign hyperplasia of the prostate is seen most frequently between the ages of 55 and 70. Various theories have been advanced to explain its etiology. The *arteriosclerotic* theory of the French was popular for many years. It was accepted because hyperplasia and arteriosclerosis occurred in patients of the same age group but pathologically and clinically this theory was eventually disproved. Not all patients with prostatic hyperplasia have arteriosclerosis and vice versa. For a while the *inflammatory* theory was accepted but here again it was later proved that inflammation, whether specific or nonspecific, played no role. The *neoplastic* theory is still disputed. Some contend that the hyperplasia represents a true new growth and others that it is pure hyperplasia. It is thought to stem from submucosal glands found beneath the mucosa of the posterior urethra and trigone. The *endocrine* theory has been advanced more recently and for some years many urologists have attempted to treat hyperplasia of the prostate with the male sex hormone and later the female sex hormone.

Carcinoma of the prostate is seen in about 20 per cent of all cases of prostatism.¹ It most frequently originates in the posterior lobe and

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occurs usually after the age of 40 but most often between the ages of 60 and 70

Contracture of the vesical neck occurs at any age—congenitally in children and between the ages of 25 and 60 in adults. It is due either to muscular hypertrophy of the internal urethral sphincter (which is comparable to congenital pylorostenosis) or to fibrosis of the vesical neck. Urethral valves are congenital but an adequate explanation has not been given for this embryonic defect.

The etiology of the neurogenic bladder is varied. Trauma to the central nervous system, syphilis, acute inflammatory diseases of the spinal cord, tumors of the spinal cord, spinal anesthesia and spina bifida are relatively frequent causes. Most urologists now agree that in the female there are glands situated in the posterior urethra morphologically similar to the prostate.² Such glands infrequently cause true bladder neck obstruction.

PATHOLOGY

The pathologic appearance of benign prostatic hyperplasia or hypertrophy varies with the size and type of gland. One lobe may be larger than another although the enlargement is usually uniform. There are seven possible lobes which may enlarge singly or in combination. However, the three most frequently encountered hypertrophied lobes are the two laterals and the median. Found hypertrophied less often are the Albarran, the anterior and the subtrigonal lobes. The cut surface of the hypertrophied prostate is light in color. Each lobe consists of smaller lobules bound together by fibrous tissue. Within the lobule there are smaller ones called spheroids. The hypertrophic or hyperplastic tissue compresses the original prostate laterally to form the surgical capsule of the hypertrophied prostate.

Most prostatic malignancies are adenocarcinomatous. The growth is usually limited by Denonvillier's fascia but it does frequently invade the seminal vesicles. Its origin is usually in the posterior lobe and from there it invades the other lobes or spreads to the urethra, bladder or rectum, the urethra being the most frequent site of invasion. The most common regions of metastasis are the lumbar spine, pelvic bones and deep pelvic lymph nodes. Nerve trunks are sometimes involved and more rarely distant bone or visceral metastases are observed.

Median bar and contracture of the vesical neck are usually the result of chronic inflammation at the bladder neck or in the prostate. The bar, composed of fibrous tissue, stretches across the floor of the internal urethral orifice and is covered by the epithelial lining of the bladder. Contracture may be associated with median bar formation and there is usually also shortening of the posterior urethra.

The same type of contracture as that encountered in adults is seen

congenitally in children. Posterior urethral valves of congenital origin appear as redundancies or folds of mucosa and are either attached to the verumontanum or are anterior or posterior to it. Occasionally, in children the interureteric ridge may become hypertrophied and produce obstruction.

Acute prostatitis, whether gonorrheal or nonspecific in origin, produces obstruction from a uniform swelling of the entire gland; occasionally, a true abscess cavity may develop within such a gland.

In all types of bladder neck obstruction the pathologic changes in the bladder itself and in the upper urinary tract are familiar. There is first hypertrophy of the detrusor muscle of the bladder with thickening of the wall. The wall of the bladder becomes trabeculated as it attempts to compensate for the increasing obstruction at its outlet. Small, herniated areas called cellules develop between the hypertrophied muscle bundles. These cellules may develop into diverticula. Later, when there is residual urine, the constant intravesical pressure may become so great that the bladder dilates and loses its tone, thus becoming decompensated, thin-walled and atonic.

As urine accumulates, infection frequently occurs and stones may form. As the intravesical pressure increases from greater retention of urine, back pressure is transmitted up the ureters to the kidneys due to destruction of the physiologic valve normally in operation at the ureterovesical junction. A reflux of urine up the ureters from the bladder may also occur. In time, the renal pelves and infundibula become dilated and the calices clubbed. Later, the renal cortex becomes compressed and thinned out with resulting loss of renal function; there may be an accompanying pyelonephritis. Pyonephrosis is the ultimate stage of this process.

SYMPTOMATOLOGY

The symptoms of obstruction at the neck of the bladder vary with the type, duration and degree of obstruction. The onset is frequently insidious. The first symptom is usually *frequency*. The patient at first pays little attention to frequency during the day but as he begins to get up at night to void, his attention is immediately focused on the genitourinary tract. Later, there may develop *difficulty in urination* with hesitancy in starting, reduced stream, starting and stopping and terminal dribbling. *Acute retention of urine* may finally appear, often precipitated by weakness resulting from some other illness. *Hematuria* may appear as gross hemorrhage with clots rapidly filling the bladder or merely as a few drops of blood terminally.

If retention of urine is of long standing, the patient often complains of weakness, lassitude, backache, pain in the legs and loss of appetite. If renal failure occurs with high blood concentration of the nitrogenous products, typical uremic symptoms supervene ending ultimately

in death. If the urine is infected chills and fever dysuria renal pain and other typical symptoms of acute pyelonephritis may develop.

Carcinoma of the prostate is essentially a silent disease until symptoms of obstruction or metastasis occur. Bone metastases or pressure on nerve trunks due to metastasis will cause backache pain in the legs and frequently typical sciatica which is undiagnosed until the prostate is considered. In the late stages rectal symptoms are sometimes predominant. Gross hematuria is infrequent. Anemia weakness and cachexia constitute the end picture as in all other malignancies.

Children with congenital obstruction are often brought in for examination because of a distended abdomen or because of straining to void with dribbling and crying from the effort required. The clinical picture may unfortunately be vague at first and consist merely of intermittent pyelonephritis with gradually developing cachexia and no obvious evidence of bladder neck obstruction until late. This fact emphasizes the necessity for a complete urologic study on any child with a urinary infection or frequency.

The neurogenic bladder presents a variety of symptoms. There may be complete retention frequency and pseudo incontinence with considerable residual urine or a true and complete incontinence similar rectal symptoms are usually also present. The history and physical examination will indicate the underlying etiology.

DIAGNOSIS

A careful history and complete physical examination are essential to make the diagnosis of bladder neck obstruction. This should include a study of the cardiovascular, respiratory and gastrointestinal systems since it is important to evaluate the patient's general health accurately before any instrumentation is planned.

The second of a two glass voided specimen of urine in the male or a catheterized specimen in the female is examined for albumin sugar red blood cells casts and finally for infection by means of a stained slide of the centrifuged sediment. Urine cultures are done when indicated. The prostate is then palpated. In benign hypertrophy there is a definite palpable enlargement usually smooth and symmetrical and rubbery in consistency. The degree of hypertrophy noted on rectal palpation however is not necessarily a true indication of the amount of obstruction present within the urethra because of the possible variations in the lobes not palpable rectally. In the presence of vesical contraction or median bar formation the prostate is small and fibrous on palpation. The carcinomatous gland is stony hard irregular and fixed on palpation and the malignancy may have extended on to the seminal vesicles and laterally beyond the confines of the prostatic capsule. In early cases palpation may reveal only a single firm nodule sit-

rounded by normal prostate. At the time of rectal examination the prostate is massaged, the vesicles stripped and the expressed secretion examined for pus in the wet fresh specimen.

Following this a phenolsulfonphthalein renal function test is done. One cubic centimeter of the dye is injected intravenously and a single specimen of urine collected by having the patient void at the end of one hour and ten minutes. A reading of 50 per cent or more for this specimen indicates satisfactory renal function with at least complete renal compensation and also demonstrates that the patient has emptied the bladder adequately. If the phenolsulfonphthalein excretion is less than 50 per cent this indicates either impaired renal function or residual urine in the bladder. A No. 18 F. coude catheter is gently introduced under aseptic conditions and the bladder emptied. The residual urine is measured and then tested for phenolsulfonphthalein excretion and the total renal function for seventy minutes obtained.

The prostate and bladder are then examined through the cystoscope in borderline cases in which the physical findings have not been thus far adequate to explain the symptoms. From this examination information is obtained regarding the type and size of the intravesical obstruction. The presence of bladder stones, tumors or diverticula can also be determined. The examination is done under local anesthesia (4 per cent metycaine) with a No. 20 F. McCarthy panendoscope and there is relatively little urethral reaction from it. In the female obstructive granular tissue at the bladder neck can be seen and, if there is a neurogenic bladder, the presence of bladder neck obstruction can be determined. In children the McCarthy miniature cystoscope is used. The child is hospitalized and cystoscopy is performed under general anesthesia. Whatever treatment is necessary is carried out at the same time with the same instrument.

Routine roentgenograms are then made in all cases. In men with definite prostatic obstruction a roentgenogram of the kidneys, ureters and bladder and cystograms are obtained. The roentgenogram of the kidneys, ureters and bladder will indicate the presence or absence of stones in the bladder or kidney, metastases to bones in cases of carcinoma or prostatic calculi. The cystograms indicate the presence of vesical diverticula and furnish information as to whether or not a diverticulum empties adequately. Large infected diverticula which do not empty spontaneously should be removed surgically prior to prostatic operation. Otherwise, the clinical result from the prostatic operation alone will be inadequate and the postoperative course of the patient stormy. Preoperative cystoscopy need not be performed in those cases with advanced and obvious prostatic enlargement, thus, a possibly serious instrumental reaction which might complicate the operation later may be avoided. Excretory urograms are also obtained in all patients with a history of hematuria or stones or anything else

pointing to possible disease in the upper urinary tract. In children excretory urography is employed routinely and has the added value of furnishing an entirely satisfactory renal function test in children too young to cooperate for the phenolsulfonphthalein test.

TREATMENT

The treatment of bladder neck obstruction is surgical. The indications for surgical intervention vary widely in individual cases. Each patient must be carefully studied over a period of time before the decision in favor of operative intervention is made.

In cases in which there is no urinary retention or only a small amount of residual urine (up to 100 cc), conservatism is indicated. If the obstruction is benign, repeated prostatic massage to eliminate any infection present as well as to empty the gland may be of considerable symptomatic benefit. The patient is instructed to avoid excessive temperature changes, too much physical exercise and long rides. The bowels should be kept regulated and alcohol and highly seasoned food should be excluded from the diet. Urinary antiseptics should be used if urinary infection is present. Renal function should be periodically checked and the amount of residual urine periodically determined. Any significant change will usually indicate the necessity for surgical intervention.

Prostatic operation is ordinarily not indicated in cases with good renal function and no appreciable residual urine. One exception to this, however, occurs in those patients who have an extremely hypertrophied bladder wall with resulting reduction of capacity and bladder irritability producing marked frequency. Surgical intervention is indicated in such cases from a purely symptomatic standpoint regardless of the presence or absence of residual urine.

There are three methods of approach for prostatic operations: the transurethral, suprapubic and perineal routes. The most popular method today is transurethral prostatic resection. It is an exacting operation, most difficult to master and attended by dangerous consequences when improperly done. However, it offers the patient with benign obstruction a satisfactory clinical result, obtained with less shock and morbidity and a lower mortality rate than any other method. Those who routinely employ this method consider it the operation of choice in all cases of benign obstruction except those presenting exceptionally extensive benign hypertrophy, in which suprapubic enucleation can be more easily and quickly performed. Suprapubic enucleation is practicable only in cases of benign hypertrophy of the prostate as a good line of cleavage between the prostatic hyperplasia and the compressed surgical capsule is essential. Radical perineal prostatectomy offers the possibility of cure in a few carefully selected cases of prostatic carcinoma and is usually employed for this purpose.

Preoperative Treatment.—Patients retaining large amounts of urine are provided with indwelling catheter drainage upon being hospitalized. There is no danger, as was formerly believed, in drawing off rapidly whatever amount of residual urine is present. A No. 18 F. coudé or Foley catheter is used. Fluids are maintained at 3000 cc. daily and are given either by mouth or by infusion of a solution of 5 per cent glucose in saline if necessary. An accurate record of the intake and output of fluid is kept. A complete blood count is obtained and whole blood given if indicated. Determinations of the blood nonprotein nitrogen, sugar, carbon dioxide and creatinine are obtained and the phenol-sulfonphthalein test is repeated if necessary. The cardiovascular system is carefully examined and any other positive findings in the history or physical examination properly studied. Should the renal function as well as all other of the above factors be satisfactory, the operation is performed. If renal function is poor, operation is postponed until the patient's condition is more favorable. The restoration of normal renal function, or at least stabilization of function in these latter cases by continuous catheter drainage and adequate fluid intake, is one of the most important factors in the success or failure of prostatic operations. It is far more important than age, a past history of severe heart disease or diabetes or any other consideration. It is the chief factor enabling urologists to operate successfully, in the presence of urine and infection, on patients in an extremely elderly age group. After prolonged catheter drainage in these cases with advanced renal damage, it matters little at what level of function the kidneys stabilize. The nonprotein nitrogen may remain constantly at seemingly prohibitive levels and yet, if properly stabilized, the patient will stand operation well.

If there is evidence of acute urinary tract infection as manifested by fever, tenderness in the kidney regions and pyuria, the patient is given a urinary antiseptic, preferably small doses of sulfathiazole or sulfadiazine, 0.5 gm., four times a day, with a teaspoonful of sodium bicarbonate. If renal function is poor, mandelic acid, 2 to 4 teaspoonfuls four times daily, may be substituted to avoid possible renal reactions from sulfonamides in already damaged kidneys.

Suprapubic cystotomy is occasionally necessary as an emergency procedure in cases of acute retention with either an impassable prostatic obstruction or urethral obstruction. It is also necessary in those patients requiring prolonged drainage prior to prostatic operation if they cannot tolerate a urethral catheter because of infection or irritability.

The same fundamental principles that apply to adults with bladder neck obstruction apply to children and preparation for operation is identical.

Neurogenic Bladder.—Recent experience has shown that transure-

thral resection of the bladder neck in cases of neurogenic bladder with partial or complete retention of urine is beneficial in almost every case. This is true regardless of the age or sex of the patient and regardless of whether or not there is any preexisting obstructive tissue at the bladder neck. The etiology of the neurogenic bladder and its duration are likewise unimportant. The improvement is most probably due to removal of the internal sphincter by resection and to the over-all enlargement of the urethrovesical junction.

Surgical Treatment—Transurethral Prostatic Resection—Transurethral resection is most frequently done with the Stern McCarthy



Fig. 515 Specimen removed by subtotal transurethral prostatic resection

electrotome and any thoroughly dependable electrosurgical unit. A subtotal prostatectomy is accomplished during which all prostatic tissue down to the surgical capsule is removed (Figs. 515, 516, 517). The anesthetic of choice for this procedure is a low spinal. Before resection is begun, bilateral vasoligation is performed to prevent postoperative epididymitis, which would otherwise occur in from 5 to 10 per cent of cases and prove of considerable annoyance during the postoperative period, possibly resulting in loss of the testis. The bladder is then carefully examined with the observation and retrograde lenses. Tumors or nonopaque stones can thus be identified if present, and removed. All prostatic tissue possible is removed out to the

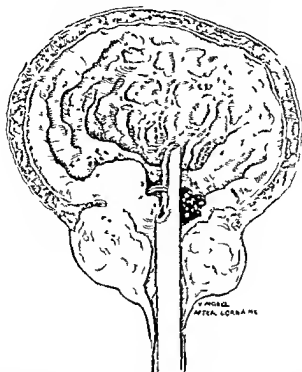


Fig 516—Diagrammatic sketch showing first stages of prostatic resection (After Lorraine, in Dodson, A I Urological Surgery, St Louis, C V Mosby Co, 1944, pp 713-719)

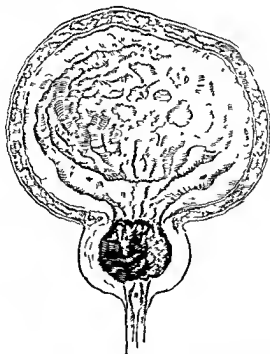


Fig 517—Diagrammatic sketch showing completed prostatic resection (Also after Lorraine)

verumontanum To obtain a good result it is necessary not only to give the patient a channel through which to void but to remove all the tissue possible This prevents recurrence of obstructing tissue minimizes infection in the remaining tissue and enables the patient to empty the bladder completely Following resection of the tissue all bleeding points are carefully coagulated and the urethra carefully checked with the Vest and retrograde lenses to be sure that no obstructing tissue remains A No 26 F Foley catheter is then introduced and the bag inflated to 80 cc The catheter is irrigated until the return fluid is clear If this is impossible, the instrument is reintroduced and further coagulation of bleeding points carried out

In children with bladder neck contracture or posterior urethral valves the McCarthy miniature operating cystoscope is used with a special small loop powered by the usual high frequency unit

Suprapubic Cystotomy—This operation is usually done under low spinal anesthesia or occasionally gas when indicated because of cardiovascular changes After the usual surgical preparation, an incision about 10 cm in length is made in the midline one to two finger breadths above the symphysis pubis The incision is carried through the skin and fascia down to the rectus sheath This is incised in the midline and the fibers of the rectus muscle separated The bladder is then distended with air by means of an insufflator The peritoneum is reflected from the anterior surface of the bladder with a gauze sponge The bladder is grasped on each side and an incision made through the wall The bladder will usually contain a slight amount of urine which should be aspirated by suction

At this stage the technic varies depending on whether a one or two stage prostatectomy is contemplated The two stage procedure has the advantage of dividing the operative shock and shortening the operating time for each procedure It also prepares the prostatic bed for later infection thereby lessening the systemic reaction after removal of the prostate However, those patients who are relatively young and in good general health can withstand a one stage procedure very well

If the operation is to be done in two stages, a finger is inserted into the bladder and the bladder explored Any stones present are removed After exploration a No 30 Pezzer catheter is inserted into the bladder and the bladder closed with two layers of interrupted chromic No 1 catgut sutures The bladder is then fixed by a chromic suture to the rectus sheath and the rectus sheath closed with interrupted chromic No 1 catgut The prevesical space is drained with a Penrose drain the external fascia closed with chromic No 1 continuous sutures and the skin closed with dermal and silkworm sutures

The second stage enucleation of the prostate is carried out when ever the patient is considered ready This may vary from a week to



Fig 518—Prostatic enucleation, showing roof of urethra being broken.

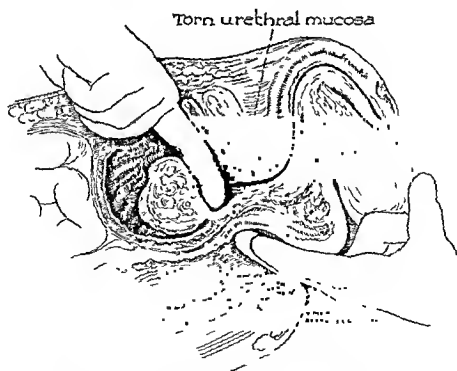


Fig 519—Prostatic enucleation showing lobes being enucleated

many months after the cystotomy depending on the amount of post operative reaction to the first operation and the general health of the patient. If necessary the second stage can be abandoned and the suprapubic catheter left in place permanently.

Prostatic Enucleation—Two fingers of one hand are inserted into the rectum and the prostate pushed anteriorly. The other hand is introduced as far into the bladder as possible from above through the same exposure as for cystotomy and the index finger introduced into the posterior urethra. The roof of the prostatic urethra is broken through first (Fig 518). A line of cleavage is then found between the hyperplasia and the compressed surgical capsule and by a sweeping motion of the finger both lateral lobes are easily enucleated (Fig 519). If the large middle lobe is hypertrophic it is enucleated at the junction of the lobe with the trigone. After enucleation the prostatic bed should be examined for any tissue left behind. Bleeding is then controlled by inserting a Pilcher bag into the prostatic cavity with its catheter end pulled out through the urethra and applying traction to this. After the bag has been inflated the urethral portion is tied to a Hunt Harmer wire cage. A Freyer tube is placed in the suprapubic opening and the wound closed as previously described. Tension on the bag must be released in six to eight hours when adequate hemostasis will have been obtained. If this is not done damage to the sphincter may result. The Pilcher bag is usually removed in from twenty four to forty eight hours and replaced by a Pezzer catheter.

The *postoperative* care of patients who have had either trans urethral or suprapubic prostatectomy is the same. In those patients who have lost a considerable amount of blood blood transfusions are given. In the first twenty four hours fluids are administered parenterally in the amount of 2000 to 3000 cc. The average patient is able to take adequate fluids by mouth after this and in forty eight hours is usually on a full diet.

The *immediate postoperative* attention to catheter drainage of the patient subjected to a transurethral operation is of utmost importance. For the first twenty four hours the catheter is irrigated regularly to assure normal continuous drainage and to remove any clots formed in the bladder. This enables the bladder to remain empty and at rest and also prevents obstruction of the catheter by clots.

The catheter is usually removed in from four to six days post operatively when the urine is clear and the patient afebrile. If the patient continues to have fever the catheter is left in several days longer. Fever when present is usually due to pyelonephritis and can be controlled by the oral administration of a good urinary antiseptic.

The patient is allowed up the day the catheter is removed and may leave the hospital in from seven to ten days. Patients who live

out of town are required to remain in the hospital through the fourteenth postoperative day, for it is usually during the second postoperative week that secondary hemorrhage occurs. If hemorrhage is severe, it can usually be controlled by emptying the bladder of clots and thorough irrigation. If bleeding continues in the presence of an indwelling catheter, coagulation of the bleeding points under anesthesia will be necessary. Before the patient leaves the hospital, the amount of residual urine should be less than 100 cc. Those patients who have had chronically distended bladders for some time preoperatively will be slow to regain bladder tone even after all obstruction has been removed and will continue to show some residual urine for a while.

The postoperative course of the patient who has undergone enucleation is longer for it usually takes ten to fourteen days for the suprapubic wound to heal and in some cases three weeks or longer. All patients should be examined postoperatively at regular intervals. All patients will have a residual urinary infection, which cannot be cleared up during the first few weeks postoperatively, as sloughing in the prostatic bed continues for at least six weeks. Urinary antiseptics, therefore, should be used only for acute flare-ups of infection with fever during this period. After six weeks it is usually possible to sterilize the urine permanently with a good urinary antiseptic.

In children excretory urograms are repeated postoperatively at six months to determine changes in the upper urinary tract following the relief of obstruction. Residual urinary infection is cleared up if possible with urinary antiseptics.

Postoperative urethral strictures frequently occur following transurethral resection, usually at the external urinary meatus or at the bladder neck. They should be repeatedly dilated during the first few months, after which, unlike other strictures, they usually resolve.

COMMENT

The treatment of carcinoma of the prostate is unsatisfactory notwithstanding recent discoveries in the field of hormonal therapy and despite the fact that a few early cases lend themselves to radical perineal removal. Aside from these few cases, the disease is admittedly incurable when first seen and all treatment is palliative.

Prostatic resection is performed when obstruction occurs in order to provide normal urination but without hope of removing the entire malignancy. Hormonal therapy as represented by the administration of stilbestrol or orchiectomy, or both, is widely used by every urologist. However, it is as yet unsettled as to how and when these measures may best be employed for the good of the patient. Consequently, there is great variation in clinical practice in this respect and no single

program of treatment has as yet been proved best. Fortunately, this question should definitely be settled in the next few years.

CONCLUSIONS

The management of bladder neck obstruction is a phase of urologic treatment in which tremendous strides have been made during the past twenty years. Patients whose disease was once considered inoperable because of advanced age or debility are now operated upon with relative safety. If the underlying physiologic and pathologic changes in the upper urinary tract in cases of bladder neck obstruction are properly cared for, the low morbidity and excellent operative results are gratifying regardless of the type of operation employed.

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ADDITIONAL ARTICLE

RADIOSURGERY: FOREIGN BODIES IN THE NECK REMOVED UNDER FLUOROSCOPIC CONTROL

• CARLOS SANTOS, M D •

THE removal of foreign bodies under direct fluoroscopic control is often discredited and considered a difficult and dangerous method

I have used this method since 1921 and have succeeded in removing, up to now, about 2000 foreign bodies without the slightest damage to the patients, my assistants or myself

In previous publications¹ I have indicated the technic I use, some new instruments I have designed, indications of the method, and so forth

It is generally believed that only foreign bodies situated in the soft parts of anatomically unimportant, nondangerous regions can be removed under the direct control of x-rays I came to quite different conclusions In order to make the possibilities of radiosurgery more widely known, I am presenting here two cases of foreign bodies situated in dangerous regions of the neck, in which I was able to effect removal under the direct control of the screen, without damage to the patients I am of the opinion that successful removal could hardly have been accomplished by any other known method

CASE I (Figs 520, 521 and 522) —A young man 22 years of age, was referred to me by Dr Alvaro Gamboa of Alpedrinha Three days earlier he had been shot in the thorax with a revolver fired at almost point blank range At the time he did not suffer much, and he had been able to walk about three miles

When I examined him, he felt slight pain on pressure in the front wall of the thorax, at a point about 8 cm above the right nipple He complained too, of dull pain in the cervical region and mild discomfort in swallowing He had a simple protective dressing over the orifice where the projectile had entered This orifice was on the right side of the anterior wall of the thorax, three fingerbreadths above and three fingerbreadths to the right of the nipple

Fluoroscopic and radiographic examination of the thorax revealed no abnormality Roentgenograms of the cervical region showed no damage in the bones but did reveal a revolver bullet, which had not lost its shape, lodged vertically point upwards, to the right of the body of the seventh cervical vertebra, slightly in front of the respective transverse process

The bullet must have passed in front of the ribs, grazing them then under the clavicle, whence it must have crossed the base of the neck to the position it was occupying

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Fig 520 (Case I) —Front view A bullet can be seen projected on the right transverse process of the 7th cervical vertebra



Fig 521 (Case I) —Side view The bullet is seen to be situated just in front of the 7th transverse process

Indications for Operation —The position of the bullet near the cord of the cervical sympathetic, near the stellate ganglion and also in proximity both to the roots of the brachial plexus and to the vertebral

artery, caused me to fear the later development of fibrous tissue which might envelop and exert pressure on the cervical sympathetic or the roots of the brachial plexus. If this occurred the necessary surgical intervention would be far more difficult than at present, and there would be risk of injury to the nerves, furthermore, it might no longer be possible to eliminate the already developed fibrous tissue with its attendant symptoms. In the circumstances, and in the light of my experience in previous cases, immediate operation under the control of the screen appeared indicated, even though the patient was not in great pain.



Fig 522 (Case I) —After the intervention. The bullet, now removed is resting on the cassette

Intervention —I operated in my own consulting room, the operation being effected in two stages, but in a single sitting.

Novocaine (0.5 per cent) with adrenalin was applied as a local anesthetic to the superficial tissues. The first stage of the intervention was carried out in the usual manner by my colleague Passos Angelo. A 3 cm incision was made at the base of the neck, in front of the anterior border of the trapezius muscle and dissection was carried out through successive layers passing behind the carotid artery, jugular vein and pneumogastric nerve to the muscular layer on the posterior surface of the supraclavicular fossa. The rest of the operation was performed by myself in the dark, by radiosurgical methods.

The special circumstances of the case prevented my following the intervention on the screen by means of the so called perpendicular ray, as usual I had to feel my way inwards in a direction parallel to the screen, which renders depth orientation infinitely more difficult.

After probing with other instruments, I employed my own curved forceps I produced, purposely, only partial anesthesia of the deeper regions in order that I might be able to guide myself by the patient's reactions. Indeed, as I gradually penetrated deeper, the patient occasionally complained of a pain radiating in the direction of his arm. This most often coincided with my receiving, transmitted from the point of the instrument, a sensation that I was touching the roots of the plexus. I had to feel my way to the bullet by means of slow and smooth perforating movements, little by little, under fluoroscopic guidance, while endeavoring to pass through parts which did not offer resistance and in which my movements caused the patient merely local pain and not the pain radiating towards his arm. As the anesthesia cannot be perfect with such a technique, it is absolutely necessary to keep the patient in good spirits by a flow of kind remarks so that he will be quiet in spite of the pain he always feels. I carefully watched the patient's general condition, and also his pupils.

Finally I succeeded in reaching the bullet and seized it transversely. Next, I proceeded gradually to extract it, by means of gentle zigzag movements, guiding myself by fluoroscopy and by feeling, so as to free it by degrees from the structures which impeded its way to the surface.

The operation occupied in all about two and a half hours. The time taken by the radiosopic intervention amounted to between half and three quarters of an hour. (Repeating what was already said in my previous works, I must insist upon the fact that such long radiosopic exposures are only possible without danger of dermatitis when a very small radiosopic field is used—in this case, for instance, never larger than one square inch.)

No hemorrhage occurred, the wound being perfectly dry when the intervention ended.

The wound was cleansed with ether. At the lower extremity of the incision, which was closed by two horse hair stitches, a small horse hair drain was placed.

After effects—At the conclusion of the intervention the patient was somewhat shocked, his pulse being rather weak. His pupils were equal and normal in size and their reactions to light were also normal. There was no abnormality in his circulation or in the sensibility or motor power of his arm.

I gave the patient a cup of coffee. He was able to get up and to walk unaided. I gave him a local application lasting thirty minutes of red and infra red rays with the Sollux lamp (as I always do in such cases). He remained lying down for another half hour, after which I saw him again. His pulse had recovered. He went home without requiring assistance.

I saw him on the following day. He had had a good night. He had practically no pain and was able to move his neck a little more freely. The wound was in a good condition. I removed the drain, which brought away a little slightly hemorrhagic serum. The patient was once more given thirty minutes under the Sollux-lamp.

The next day, when I saw him again, he was feeling better, the pain having further lessened and movements having become still more easy. I removed the stitches. Where the lower stitch had been, there was a tiny opening of about 1 mm in size, whence a drop of blood oozed. I applied iodized alcohol and an aseptic dressing. The patient left the same day for his village in the country—that is to say, just two days after the operation.

Later I learned that this patient made a quick and perfect recovery, no complications having developed.

CASE II (See Figs 523 to 526).—A policeman had been shot with a revolver six days before I saw him for the first time. I was informed that after the accident he had walked about two miles.

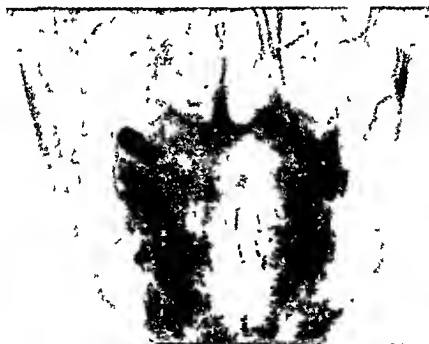


Fig 523 (Case II).—Front view. A bullet is seen projected on the right maxillary sinus of the patient.

I found a painful swelling of the soft parts of the right side of the face. The entrance wound of the bullet (already closed) was situated about 1 cm above the right angle of the mouth. There was a hematoma of the soft palate on the right side and trismus was present.

Röntgenograms of the head, one from the occipitofrontal angle, one exactly in profile and one in the usual oblique position for the separate projection of the right side of the lower jaw, were made. The films show several fracture lines in the ascending ramus and coronoid process of the right lower jaw, without displacement of the different fragments. A revolver bullet with a slight deformation is to be seen. It can be localized in the soft parts of the right side of the neck.



Fig 524 (Case II) -Side view It is apparent that the bullet is situated in the soft parts of the neck between the pharynx and the neurovascular sheath at the level of the 1st cervical vertebra



Fig 525 (Case II) -Oblique view Several fracture lines can be detected in the lower jaw

about 3 cm. to the inner side of the posterior border of the ascending ramus of the lower jaw at the level of the body of the first cervical vertebra. I estimated that the bullet in this location must be situated between the pharynx and the neurovascular sheath, under the arteria maxillaris interna, in the region of the pterygoid venous plexus, in near relationship to the inferior dental and the lingual nerves.



Fig 526 (Case II) —Side view after the intervention. A clip placed at the wound on the skin projected between teeth 3 and 4 of the upper jaw.

The patient brought with him some roentgenograms taken three days earlier in which the foreign body could be seen in contact with the lower surface of the inferior wall of the skull, i.e., about 3 cm. above the situation it had now.

Indications for Operation—Although the bullet was supposed to be somewhat free in the tissues of the neck (otherwise it would not have moved down since the first film) it did not move about during palpation. As in the first case, it was reasonable to expect that later formation of the usual granuloma would interfere with some of the local nerves, making operation far more difficult. Immediate intervention was indicated if the foreign body could be removed without great danger or great trauma. I thought that this was possible.

Surgical Approach.—The shortest route, from the side of the neck, was dangerous because of the proximity of the parotid gland, the facial nerve and the neurovascular sheath. Examining the patient under the screen, I saw the possibility of taking another route which, although much longer, was free from danger. With the patient under the screen, his head in an oblique position (R.A.O.), I could see the

foreign body projecting between the upper and the lower jaw In this position the only anatomical features which I would have to avoid were Stenon's duct and the inferior dental and the lingual nerves in the neighborhood of the foreign body no violent movements would be permissible, lest contact be made with the pterygoid venous plexus. I would have to be careful not to move the forceps towards the external side of the foreign body, in order to avoid contact with the neurovascular sheath, to the inner side, in order to avoid damaging the wall of the pharynx, or to the posterior side, in order to avoid contact with the last cranial nerves It seemed to me these pitfalls could be avoided

Intervention—The operation was performed in my consulting room the day after my first observation I anesthetized the soft parts of the face with novocaine (0.5 per cent) and adrenalin I next inserted a needle from the outer aspect of the face pointing backwards and inwards until the patient indicated a pain in the teeth in order to determine the position of the inferior dental nerve Then I placed the head of the patient in a position that would permit me to move in a straight line from the skin to the foreign body without touching this nerve, but just passing it by After anesthetizing (not very completely) the deeper parts, I made a horizontal incision of 12 mm through the skin about 3 cm above and lateral to the angle of the mouth The incision was made only in the epidermis and dermis, in order to by pass Stenon's duct with certainty

I next inserted through the wound a special pair of forceps of my own construction (the same referred to in the aforementioned case) These forceps have their extremity somewhat wedge shaped so that they can separate the tissues, and easily pass between the fibers of muscles or between nerves or vessels As the borders are not sharp these forceps simply push aside, rather than cut the different tissues The borders have no indentations

As the face was swollen, I could easily pass the forceps without touching the mucosa of the mouth, thus avoiding infection of the operative wound (I had not chosen the oral route originally because of the danger of infection) I passed outside the buccinator muscle until I touched the anterior border of the coronoid process Then I took an oblique course between the upper and the lower jaw, through Bichat's pad of fat (the sucking pad of infants) I came to the region where the bullet was situated All the time I was "probing" my way as it were, by slow, smooth perforating movements When I came in contact with the bullet, I had the sensation of reaching a sort of cavity where the movements were freer When I tried to grasp the foreign body, however it slipped easily from the jaws of the forceps which were too small for such a bullet It was evident that a larger pair of forceps was required When pulling back my first forceps I opened

them and tried to increase the size of the channel I had made from the skin to the foreign body in order to facilitate the introduction of the larger pair

With the larger forceps, which were similar in construction to the first pair, I was able to grasp the foreign body lengthwise and remove it without great difficulty

This operation was much easier than in Case I. It took about twenty five minutes altogether

No hemorrhage occurred, the wound being dry at the end of the intervention. No nervous lesions of any kind complicated the procedure. One clip was sufficient to close the wound

After effects—After the intervention I made the usual application of red and infra red rays with the Sollux lamp (thirty minutes). The patient walked out unaided and came back daily for six days to have other applications of the Sollux lamp. Through a misunderstanding of my instructions the clip was not removed on the second day as is customary in my cases of this nature but on the third day

The fracture caused this patient discomfort for a certain time, some swelling and tinnitus but from the foreign body and from the intervention not the slightest complication has appeared and later all symptoms disappeared completely

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SYMPOSIUM ON SURGICAL PHYSIOLOGY

FOREWORD

THE advances in our knowledge of normal function, of the abnormalities from the normal which occur in disease and the effect of these on biologic processes make it mandatory that the surgeon be more than a mere operator. The operation will always remain the most dramatic part of surgical therapeutics, but thorough, painstaking preoperative and postoperative care plays an ever-increasing role in the end results of operative procedures. By a successful operation we now mean a well patient. The surgeon now accepts complete responsibility for the preoperative and postoperative care of the patient.

A full understanding of the factors influencing morbidity and mortality requires a wider appreciation of the collateral circumstances which attend surgical disease and the complications attending anesthesia and operation. This volume is presented to provide in brief form a variety of subjects of major importance to surgeons. It is not a monograph of surgical physiology or of biochemistry in surgical disease. The subjects have been chosen because of the author's interest in specific fields. There are without doubt other subjects of equal, or even greater interest to surgeons, but the size of this volume is limited. It is hoped that the essays contained herein will provide useful information on the pathologic physiology of certain processes.

The foundation of modern surgical therapy has become broader and firmer. This circumstance has come about as the clinician has become more familiar with the factors governing normal function. In this volume will be found what may occur when disease, anesthesia or operation causes abnormalities of normal function. Such circumstances are of interest to the surgeon regardless of the specific field of surgery in which his major interest lies.

I S RAVDIN, M D
Consulting Editor

PROTEIN DEFICIENCY IN SURGICAL PATIENTS

I S RAYDEN, M.D., F.A.C.S.*

PROTEIN deficiency as seen in surgical patients is nearly always a complicated phenomenon. The deficiency is, as a rule, associated with an inadequate intake of the primary foodstuffs as well as one or more of the known vitamins. Prolonged subsistence on minimal levels of protein intake is hazardous. Normal growth and normal utilization of protein depend upon the presence of eight to ten essential amino acids.¹ There are frequently associated alterations in the fluid and electrolyte balance and stores of the body, as Doctor Abbott² has pointed out. To maintain good nutrition in adequate amount and an adequate variety of various primary and accessory foodstuffs, minerals and water must be ingested and these must be absorbed and utilized in the body economy.

This chapter will concern itself with certain aspects of protein deficiency in surgical patients. A deficiency in the protein nutrition results in many changes in physiological activity, and certain of these changes can be demonstrated before serious protein starvation is evident.

Proteins are an important part of all cells, including the nuclei. The enzymes, hormones and antibodies of man are in the main protein in character. The plasma proteins, through their colloid osmotic effect, play an important role in maintaining normal relations between intracellular and extracellular body fluid.

The plasma proteins consist of two main groups, the albumins and the globulins. Each of the subfractions has specific physiological functions. Serum albumin is responsible for approximately 85 per cent of the colloid osmotic effect of the plasma proteins. Fibrinogen, prothrombin and the antibodies are found in the globulin fractions. Protein undernutrition is first manifested by a fall in serum albumin concentration, although if means to determine it were available, the first effect of protein undernutrition is a reduction in the amount of protein stored in the tissues of the body, since every attempt is made to maintain the serum protein concentration at a nearly normal level. In this sense, hypoproteinemia, either in the total of circulating protein or its concentration, is indicative of a reduction in the "labile" or reserve stores of body protein.

The restoration to normal of a reduced serum protein content must

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not be taken as an indication that the tissue deficit of protein has been restored, for depleted reserve stores of protein are not, as a rule, significantly replenished until the concentration and total amount of serum protein have returned to normal.

Gross evident edema does not, as a rule, occur when the serum albumin is greater than 3 gm per 100 cc and is, as a rule, present when it is less than 2.5 gm per 100 cc. The administration of large amounts of neutral sodium salts to patients will increase the edema which may occur at any given level of the plasma protein. The parenteral administration of fluids in pre- and postoperative care should, therefore, be carried out with rare judgment. As soon as the concentration of serum albumin falls below the accepted normal, a graded retention of fluid takes place. Palpable edema indicates that the serum albumin concentration has reached a critical level or that serious malnutrition has occurred.⁴⁵

When anemia and hypoproteinemia coexist, it is important that the patient be provided adequate protein and iron for hemoglobin synthesis and an additional amount for protein storage and plasma protein regeneration. If this is not done, hemoglobin synthesis will take place at the expense of protein storage and plasma protein regeneration.

The determination of nitrogen balance is important in protein nutrition for by this means only can it be known whether protein is being stored in the body or lost from it. An individual is in positive nitrogen balance if the intake of nitrogen by mouth or parenterally exceeds the amount lost from the body by all means and in negative nitrogen balance if output exceeds the intake. In considering output it is important to take into account not only the output in the urine, but also that lost from wounds and through suppuration. A negative balance occurs when there is excessive breakdown of body protein, abnormal loss from any source or when protein intake is inadequate. A positive balance occurs when the intake of foodstuffs is adequate both in the amount of protein and in total calories. Although a positive nitrogen balance may be obtained on a relatively low protein intake if the caloric intake, especially of carbohydrate is adequate such a dietary is not safe over long periods for it does not provide for sudden demands during illness or injury.

Forced feeding considerably in excess of the daily requirements leads to the building up of the food stores of the body. A large portion of the excess protein in such dietaries is stored as reserve protein and can be called upon during periods of stress and strain without requiring the catabolism of important fixed cellular protein.

Proteins are not alike in their nutritive value, for they vary greatly in their content of the nutritionally essential amino acids. The proteins of animals are, as a rule, complete proteins, although even in this group considerable variations are found in the content of the essential

amino acids Gelatin, which is of animal origin, is an incomplete protein and when used in the dietary should be supplemented by proteins which contain the missing essential amino acids The vegetable proteins are not so likely to be complete proteins Supplementation is, as a rule, considered excellent nutritional practice, but supplementation must take into account the necessity of providing in the protein ingested or injected, all of the essential amino acids

According to Peters and Van Slyke,³ serum albumin can be regenerated at the rate of 25 gm or more per day depending upon the adequacy of the dietary intake provided that protein is not being lost in excessive amounts from the body

THE CAUSES OF PROTEIN DEFICIENCY

In general there are five major causes of protein deficiency

1 The Insufficient Intake of Protein (Chronic Malnutrition).—This condition, in the traditional sense, results when there is an inadequate intake of protein to meet the nutritive and metabolic demands of the body There may be an absolute quantitative deficiency in protein intake, or the protein, while quantitatively sufficient, may be qualitatively inadequate in that as ingested it fails to provide the amino acids essential for a good nutritive state Very frequently the deficiency results from an intake quantitatively and qualitatively inadequate

Youmans and his associates⁴ have studied this condition in certain areas of our own country The external evidences of prolonged protein undernutrition may not be readily evident until the individual is subjected to the increased demands associated with illness or injury

At times an inadequate intake is imposed upon the patient by a physician or surgeon ignorant of nutritional requirements At others the patient restricts intake because of pain, anorexia, nausea or vomiting

The restricted food intake of the chronic alcoholic is another example of this type of deficiency There results a serious loss in the reserve stores of protein, anemia and hypoproteinemia together with the events that follow these biologic abnormalities It is more than possible that herein lies in large part the danger of alcoholism

2 Impaired Digestion or Absorption of Protein.—These conditions are found in certain chronic diseases of the gastrointestinal tract associated with abnormalities in the secretory activity of the stomach, small intestine, pancreas or * * * * * may occur in patients with intestinal ulcer lesions or edema of the air

rhea It is at times seen in the presence of fistulas of the small bowel and is constantly observed in gastrojejunocolic fistula

The nutritional deficiencies observed in this group are nearly always complex ones and are within a brief period associated with anorexia and a further restriction in the intake of food Such a vicious circle

results in an intensification of the dietary deficiencies and a further drain upon the tissues of the body

3 Impaired Protein Synthesis.—The liver is inseparably associated with protein synthesis. It is generally agreed that albumin and fibrinogen are formed in the liver. Certain globulin fractions are without doubt normally synthesized in part in the liver. Addis and his associates⁶ demonstrated that the liver contains under normal conditions a readily mobilizable reserve store of protein which is depleted during fasting and restored following adequate feeding. Addis has called this readily depleted protein "labile protein." While it cannot be demonstrated that this "labile" or "reserve" protein is chemically different from the general cytoplasmic protein, it can easily be demonstrated in the rat that during a seven day period of fasting the liver rapidly loses as much as 40 per cent of its total protein and as rapidly regains it following a period of completely adequate feeding.

In the presence of severe hepatic disease, acute or chronic, protein synthesis is disturbed. Myers and Keefer⁷ found that albumin synthesis was more severely disturbed in hepatic cirrhosis than was globulin synthesis. The disturbance may be sufficiently great to result in the inversion of the normal albumin globulin ratio. There results not only hypoproteinemia but a serious reduction in the stores of reserve protein in the body.

The protein deficiency which results from serious hepatic disease may not be due to an insufficient protein intake although it may be a factor in the milder cirrhoses. It is due to a fundamental disturbance of function which prevents the liver from utilizing in a normal manner the amino acids as building stones for protein synthesis.

In many hepatic disorders, the cirrhoses, toxic and infectious hepatitis, and primary and secondary malignancy, the disturbance in protein synthesis usually parallels the degree of hepatocellular injury and destruction. In the absence of proteinuria and other discernible causes of protein loss, and with an adequate intake of protein, hypoproteinemia and its sequelae, or associated phenomena, should be considered as evidence of inadequate protein synthesis.

4 Increased Loss of Protein from the Body.—Some protein, in the form of the nitrogenous products of protein catabolism, is constantly excreted in the urine. This is a normal mechanism and provides for the disposal of such nitrogenous material as is no longer useful in the body economy.

The amount of protein lost in the urine in certain lesions of the kidney may, however, be so great that under none of the conditions now available can the protein deficiency be corrected until a more normal renal function is established. Here again the fraction of the serum protein which suffers to the greatest degree is the albumin.

In the dysenteries and in colitis, especially ulcerative colitis, the loss of plasma and blood may be considerable, and in addition there is

frequently an impaired absorption of protein. In long standing suppuration, in conditions associated with internal exudates or transudates, as in peritonitis and thoracic empyema, and in extensive superficial injury, such as large superficial burns, the loss of plasma protein may be very great.

In addition, in most of these conditions there is apt to occur an increasing anemia unless special efforts are made to prevent it. The significance of an anemia, especially a marked reduction of the hemoglobin in the presence of a protein deficiency, must be clearly understood.

Whipple⁸ has summarized this relationship as follows: "We believed that in a dog, both anemic and plasma depleted, we could influence the protein flow toward hemoglobin by one food factor or toward plasma protein by another food . . . To our surprise we observed that such dogs (hemoglobin and plasma protein deficient) always produce more hemoglobin than plasma protein no matter what diet protein is used. Hemoglobin in its production may draw on the plasma protein but hemoglobin stands apart in the protein economy and does not contribute freely to the protein pool. On the other hand, the body guards jealously the fabrication of hemoglobin and given a real need for both plasma protein and hemoglobin the protein flow favors hemoglobin, which under these circumstances is produced in more abundance than the plasma protein." Every possible effort, therefore, should be made to correct an existing anemia in protein deficient surgical patients.

5 Increased Catabolism of Protein in the Body.—Some protein is constantly being broken down in the normal processes of metabolism. In fever, in hyperthyroidism, as well as in other conditions associated with an increase in the metabolic rate, such as myelogenous leukemia, there occurs a marked increase in the rate of protein breakdown. In the severe infections even those unassociated with suppuration a rapidly developing hypoproteinemia may be observed.

The effect of such a disturbance on the hemodynamics of the circulation may be considerable. We have shown,⁹ as have others, that the hypoproteinemic dog is more susceptible to hemorrhagic shock, and no one would question the increased susceptibility of the undemourished individual to traumatic shock.

Cannon and his associates¹⁰ in a series of important contributions have pointed out the close relationship existing between protein deficiency and an inability to develop adequate antibodies. This very important field is just now being rapidly extended but the knowledge already gained begins to complete the mosaic, which was previously fragmentary, regarding the relationship between the nutritional state and the general resistance of the patient. The work of this group is of paramount importance to the surgeon.

Rose and I¹¹ have repeatedly observed that the failure of a patient

suffering from hyperthyroidism to gain weight during the period of preoperative therapy may be of serious consequence in that the morbidity and mortality of operation is increased in such patients

The body requirements of protein cannot fail to be met even for relatively short periods in those subjected to serious acute illness or injury without profound physiological changes. When a deficiency of such requirements occurs over relatively protracted periods, morbidity is increased, convalescence is retarded and the mortality of a variety of conditions will be increased. Tillett and his associates¹² have shown that a rapid loss of serum and tissue protein may be an important factor in the cause of death of patients following severe bacterial infection even when the infection has been controlled by chemotherapy. This entire field which is only now receiving the attention of competent investigators will without doubt provide information of great value in the care of our patients. When it is considered that following even relatively minor operations there takes place a marked increase in protein catabolism and following major procedures a more extensive protein breakdown, the significance of an adequate nutritive state becomes even more apparent.

SOME SURGICAL PROBLEMS OF PROTEIN DEFICIENCY

The selection of a few illustrations of the specific effects of protein deficiency must of course be conditioned by one's interests, both clinical and experimental. As a surgeon my attention has been directed to a few of the conditions resulting from periods of protein deficiency. I shall describe certain of these although I might well have selected many others of equal or even greater significance.

Lund and Levenson¹³ in an excellent review have called attention to the importance of correcting protein deficiencies in shock in local or general hypoproteinemic edema in the healing of wounds in infection and in the detoxification of certain noxious substances. To these should be added the importance of correcting a protein deficiency during convalescence for it is at such a period that a great deal can be accomplished in facilitating a speedy and complete recovery.

Every operation every injury and infection is associated with a period of increased nitrogen catabolism resulting in most instances in a negative nitrogen balance. Cuthbertson¹⁴ has shown that a negative nitrogen balance occurs for a period of time after a simple fracture, and Rhoads and Kasinskas¹⁵ have shown that a serious protein deficiency retards the healing of fractures.

Wound Healing—In 1934 Harvey¹⁶ in the discussion of a paper on wound disruption by Meleney and Howes¹⁷ stated: "There are constitutional alterations which may lead to weakening of the wound. In a young infant badly nourished with pyloric stenosis for instance the wound is not likely to heal well. With carcinoma of the stomach the wound is not likely to heal well. Senility per se has nothing to do

with it but with extreme malnutrition and anemia the wound will not heal well. In 1935 Smelo¹⁸ working in our laboratories on certain aspects of superficial wound healing concluded that "factors other than the local dressing appear to play the dominant role determining the rate of wound healing."

We¹⁹ have shown that dogs which have been made protein deficient by plasmapheresis and prolonged feeding of a low protein diet but amply supplied with the known vitamins have a marked delay in fibroblastic proliferation. The hypoproteinemia in our dogs was but one easily measurable indication of protein starvation. We were at first inclined to attribute the delay in fibroblastic proliferation to the presence of edema and it very likely plays a part, but we believe that the mechanism is in large part associated with a profound disturbance in protein metabolism.

Admont Clark²⁰ showed that on a diet high in protein there was no quiescent period in the repair of wounds, and Harvey and Howes²¹ have reported that such a diet causes accelerated fibroblastic proliferation.

Hartzell Winfield and Irvin²² have found hypoproteinemia to be more frequent in patients with wound disruption than is a vitamin C deficiency and Mulholland and his co-workers²³ and many others have now demonstrated the amazing healing which can take place in certain decubitus ulcers when nothing else is changed in the care of these patients except the addition of an adequate amount of protein to the diet.

Hypoproteinemia and Edema—Jones and Eaton²⁴ first reported that edema resulting from hypoproteinemia was not uncommon in patients before and after operation for gastrointestinal lesions especially those of the stomach and duodenum. The large amounts of sodium chloride given such patients to overcome their dehydration serve to intensify the edema occurring at any given concentration of the plasma protein.

Hypoproteinemia may give rise to so intense an edema following a gastrointestinal anastomosis as to mimic in every way a mechanical defect in the anastomosis.^{25, 26} The impediment to normal gastrointestinal flow is frequently the result of an accentuation and prolongation of the edema associated with hypoproteinemia and the trauma of operation.

On a number of occasions we have seen such stomata fail to function normally until by one means or another the hypoproteinemia was overcome. When this was accomplished normal emptying took place and the fear that the complication was due to a defect in the method of anastomosis gave way to the feeling that we should pay more attention to nutrition and the factors which are responsible for keeping fluids in blood vessels.

Fractures—Cuthbertson¹⁴ found evidences of a markedly negative

nitrogen balance following fractures. The nitrogen lost in the urine was as great as 25 gm. for twenty-four hours, and a negative nitrogen balance continued for many days unless strenuous attempts to increase the intake of protein were made.

Rhoads and Kasinskas¹⁵ have shown that a deficiency of protein markedly affects bone healing. Dogs rendered protein deficient showed a marked delay in bone healing. They found that sometimes for as long as seventy-six days after a division of a bone in hypoproteinemic animals there was little evidence of callus formation, while the animals with normal protein stores showed good callus formation at the end of thirty-nine days.

Liver Damage and Liver Regeneration.—Thirty-four years ago Opie and Alford^{27, 28, 29} reported that the incidence of necrosis of the liver following the use of chloroform could be greatly reduced if a diet high in carbohydrate was administered to dogs for several days prior to anesthetization and that increased susceptibility occurred if the diet was high in fat. Surgeons, internists and even physiologists apparently accepted the data which these investigators presented, this in spite of the fact that Moise and Smith,³⁰ in 1934, called attention to the inadequacies of the diets used by these early investigators. These diets were neither pure nor adequate to meet the energy requirements of growing dogs.

Data which Goldschmidt, Vars and I³¹ have obtained demonstrate that a liver high in lipid content and low in available protein is maximally susceptible to injury following chloroform anesthesia, while a liver low in lipid content and high in available protein is maximally protected against injury. Even in the presence of a high concentration of liver lipid we found that a diet adequate in its protein and caloric content and administered for several days prior to anesthetization greatly reduced the incidence of necrosis of the liver.

Whipple and his co-workers^{32, 33} have since confirmed our data showing that a diet adequate in protein will protect the liver from injury during chloroform necrosis. They have extended these observations by demonstrating that a similar diet protects the liver from arsphenamine necrosis, while Smith³⁴ has found that it protects the liver from selenium poisoning.

More recently Miller, Ross and Whipple³⁵ have stated that methionine and to a lesser extent cystine are the active fractions of the protein molecule which offer this protection against chloroform.

Nitrogen Imbalance After Operation.—Not only does a protein deficiency exist in many instances prior to operation, but the increase in protein catabolism which is brought on by many operations may induce this or intensify it subsequent to operation. This is all the more true when extensive tissue trauma leads to exudation or when infection supervenes. Elman³⁶ found that the negative balance after certain operations was such as to result in a rapidly increasing protein

deficiency, and Browne, Schenker and Stevenson's⁴⁷ studies confirm those of Elman

Although the protein stores may appear adequate, hemorrhage, serum loss, infection and suppuration, and the increased protein catabolism following operation may result in such a drain on the available stores of protein as to initiate a series of complications which in spite of a technically perfect operation may cause a fatal ending

The Correction of Protein Deficiency.—We have used various methods in attempting to sustain or reinforce the protein stores of the body both before and after operation. The exact method used in any given instance must depend upon a number of factors. On one thing all investigators are agreed, the best route to supply the energy requirements of a patient and to add to the various stores of body foodstuffs is the oral route. When there exists no contraindication to oral or orojunal feeding, other routes should not be used except for supplementary feeding.

The diet should be one which the patient will eat. It is not what is offered the patient that counts, it is what he actually eats. Since nearly all deficiencies are mixed ones, the dietary when offered by mouth should be ample for good nutrition.

The ordinary patient does well on a protein intake of 1 gm per kilogram of body weight per day. During short periods even this amount may be reduced if sufficient carbohydrate is added to the diet. In extensive superficial burns and extensive trauma of other types, and in severe infections, especially those associated with suppuration, the protein intake should be greatly increased. A positive nitrogen balance may not be obtainable in the presence of acute injury or infection under any program of feeding. Not only are large amounts of protein often necessary—amounts as high as 300 gm per day—but the total caloric intake should likewise be increased from 2000 to 2500 to 3500 to 4000 calories a day.

We have found⁴⁸ that after major abdominal operations, such as a gastric resection, mixed jejunal feedings in which the twenty four hour intake of nitrogen is 0.3 gm and the caloric intake not less than 30 calories per kilogram of body weight will usually result in a positive nitrogen balance. These amounts in our experience must be increased when parenteral feeding alone is resorted to.

When oral feeding is used, whole foodstuffs should be given. There is no beneficence in feeding protein hydrolysates unless definite evidence of faulty digestion is available. Feeding of mixtures of polypeptides and amino acids may result in an absorption rate of amino acids which is more rapid than can be resynthesized by the liver, especially when the function of this organ is not normal.

Koop and his associates⁴⁹ have provided good evidence that forced feeding prior to operation is of real value if this can be done, for while the amount of nitrogen lost in the urine subsequent to operation may

still be considerable, the amount of nitrogen stored as protein by the forced feeding leaves the patient with a credit in his storehouses

One of the most important and fascinating developments in post-operative care has been the wider application of early ambulation. As this has been extended, surgeons have given more specific attention to convalescence and reconditioning beginning with the period immediately after operation. In order that this be achieved it is important to increase the consumption of foodstuffs. It is only in this way that the losses encountered during periods of underfeeding, illness and injury can be promptly corrected, and physical rehabilitation be facilitated.

After the immediate crisis of the operation has passed, the patient should be placed on a diet containing 125 to 150 gm of protein with sufficient carbohydrate and fat to provide from 2600 to 3500 calories per day.

There are other means of supplying foodstuffs when the voluntary ingestion is impossible or when only small amounts can be administered by this route. It is possible to use *protein hydrolysates by tube feeding* into the stomach or jejunum in conjunction with glucose and even fat. In our experience diarrhea very often results when large amounts are fed in this manner. Protein can be administered as human plasma, human albumin, as hydrolysates of casein or fibrin, as gelatin or as whole blood.

There are practical contraindications to the use of large amounts of *plasma* or *albumin intravenously* for replenishing chronic protein deficits. The increased blood volume which occurs following their use may increase the circulating volume to a degree which may lead to cardiac embarrassment. These substances are very useful during temporary periods of hepatic insufficiency, but they are expensive and evidence is available that they do not serve adequately for long periods as the only source of protein in the presence of serious protein deficits.

Casein, *lactalbumin* and *fibrin hydrolysates* have been widely used intravenously reinforced with glucose to increase the total caloric intake. It has been found that when they are administered in sufficient amounts—0.5 gm of nitrogen and 30 calories per kilogram of body weight per day—a positive nitrogen balance can usually be maintained.

Gelatin in our hands has proved to be an excellent plasma substitute when an acute plasma deficiency exists. Gelatin is, however, not a complete protein in that it is lacking in certain of the essential amino acids, so that it is an unsatisfactory source of nutritional protein. Recently Brunschwig⁴⁰ has published data which suggest that, reinforced with the necessary essential amino acids which are lacking in gelatin, a positive nitrogen balance can be maintained, and Riegel⁴¹ and others have shown that when a protein hydrolysate and gelatin are used in equal amounts in terms of nitrogen, a positive balance is attainable.

Whole blood is useful in overcoming an anemia in protein deficient patients but it is not an economical source of protein in protein deficiency

A considerable amount of literature has been built up on the value of the sulfur containing amino acids, especially *methionine*, in protecting the liver from certain noxious agents, in reducing the nitrogen lost in the urine after severe injury⁴² and in the repair of injured viscera⁴³ There can be no doubt but that methionine is at times useful in all of these conditions but all investigators are not in agreement regarding its usefulness⁴⁴ In attempting to reconcile the negative results of some investigators with the positive ones reported by others, I have been impressed by the fact that unsuccessful results have been obtained in animal and clinical investigations where the dietary being fed had for some time been ample in its protein and in its methionine content On the other hand when for a period a protein deficiency had existed the administration of methionine supplementation in man subsisting on a dietary containing 40 gm of protein and adequate carbohydrate and fat will not result in a reduction in the nitrogen lost in the urine, but it will do so on a similar isocaloric dietary where the protein is reduced to 20 gm daily It is important to stress the point that methionine has been proved of value only when the dietary has been inadequate Its usefulness, therefore depends upon whether or not the patient is already receiving an optimal amount of methionine in the daily ration

CONCLUSIONS

More intelligent efforts must be directed toward improving the general nutrition of patients suffering from surgical lesions if there is to result a further lowering of the morbidity of these conditions a reduction in their mortality greater safety of radical operative procedures and in a shortening of the period of convalescence The protection of the protein reserves of the body or their restoration should they have become depleted is of primary importance The most rapid means of restoring nutritional deficiencies is to feed the patient by mouth a diet adequate in composition and in total calories The intravenous route should be used only when the oral route cannot be used or to supplement oral intake

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NEWER CONCEPTS OF THE PATHOLOGIC PHYSIOLOGY OF SHOCK; PERIPHERAL CIRCULATORY COLLAPSE

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UNDER the stimulus of World War II, numerous researches have been carried on during the past five years to investigate the mechanism of peripheral circulatory collapse. These observations necessitate changes in the concepts previously held concerning the nature of this condition. In an article published in December, 1941,¹ shock was defined as "the clinical condition characterized by progressive loss of circulating blood volume resulting from increased capillary permeability." Recent investigations by a number of observers have cast doubt upon the concept that there is a generalized increase in the permeability of the capillaries in regions remote from trauma. Again, it has been irrefutably shown that the progressive fall in blood pressure in the late stages of shock is not corrected by a restoration of blood volume. Clearly a reorientation is necessary.

BLOOD VOLUME

Wiggers² in his comprehensive review of shock in 1942 concluded that "a reduction of the effective circulating volume and blood pressure are of basic importance." Full confirmation of this statement with regard to the immediate mechanism of traumatic shock was afforded by the brilliant investigations of the group of workers at Bellevue Hospital in New York. Under the direction of Cournand³ and by means of special techniques developed for the study of cardiovascular hemodynamics, measurements were made on patients which replaced the assumptions based on previous laboratory investigations in animals. Richards⁴ has summarized the findings of these investigators in the following statement: "The essential finding in all appeared to be an inadequate venous return of blood to the heart with diminished cardiac output. The anatomical factor immediately responsible for this, in most instances, was a deficit in circulating blood volume." The extent of the reduction in blood volume was directly proportional to the magnitude of the injuries. There was a close correlation also between the degree of reduction in blood volume and the severity of the shock which the patients exhibited. A blood volume 30 to 40 per cent below normal, according to Noble and Gregersen,⁵ was not an uncommon finding in cases of severe shock. The blood volumes of casualties were determined within a few hours of wounding as a part

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of careful studies by Stewart and Warner⁶ and by Emerson and Ebert.⁷ A reduction of 40 per cent was usually found in those patients in severe shock. Evans⁸ in Richmond observed a similar reduction in blood volume in the patients whom he studied. On the other hand in cases of abdominal injury even though the degree of shock apparent on clinical examination and the actual failure of the circulation as measured by reduction in cardiac output were of comparable degree the total blood volume showed only a relatively small decrease below the limits of normal. In addition to the traumatic injury these patients were suffering from peritonitis and infection. Ebert and Stead⁹ had previously reported their clinical observations on the shock which is recognized to follow certain severe infections. They found that the blood volume might be normal even though other measurements of the circulation indicated a profound peripheral vascular collapse. Emerson and Ebert⁷ described some cases of shock notably those associated with severe abdominal injuries or with prolonged hypotension in which circulatory failure persisted in spite of a demonstrably satisfactory replacement of blood volume. In the presence of severe infection or prolonged hypotension some other explanation rather than reduced blood volume must be considered in order to explain the circulatory failure.

CAPILLARY PERMEABILITY

Many of the former concepts of shock postulated a generalized increase in capillary permeability as the mechanism for the loss of plasma from the circulation. This supposed change in permeability was considered to be due to the action of toxins absorbed from traumatized areas or to result from anoxia due to reduced circulation. By some increased capillary permeability was considered to be one of the initiating factors in shock and by many it was thought of at least as a contributing or sustaining agency. Direct studies of capillary permeability by numerous investigators have generally failed to demonstrate loss of plasma from the blood stream other than into the region of injury. The only positive evidence for such an increased loss was in the observations reported by Netsky and Leiter¹⁰ on the appearance of protein from the blood stream in the cervical lymph following burns. They identified this protein by immunologic methods. Studies by Cope and Moore¹¹ who tagged the protein with radioactive elements failed to confirm these observations. In only one experiment late in shock did an increase in capillary permeability appear in an area remote from trauma. Additional evidence against the theory of increased capillary permeability was advanced by Noble and Creger¹² and by Price and his associates.¹³ They observed no significant differences in the slopes of the curves for the disappearance of the dye T 1824 from the blood stream in clinical or experimental shock. This evidence does not appear to be significant. Since the dye is bound

to the protein, change in its concentration could only reflect selective loss of either dye containing plasma or dye-free fluid from the blood stream. Loss of whole plasma would not change the concentration of the dye in the circulating plasma.

Of greater import are the observations of Fine and Seligman^{14, 15}. By the use of plasma proteins tagged with radioactive isotopes they examined the capillary leakage hypothesis in hemorrhagic, tourniquet and burn shock. They found that the tagged plasma proteins escaped in considerable quantities into the traumatized areas but not into regions remote from trauma. Only in the late stages of shock and after the administration of large quantities of saline was there evidence of the passage of significant amounts of plasma into nontraumatized areas. Howland and Mahoney,¹⁶ by means of fluid-balance studies, noted loss of plasma only into regions of injury in untreated shock produced by intestinal manipulation. However, in animals treated with plasma a large amount of fluid was not recovered, indicating a generalized increase in capillary permeability.

In shock produced by tourniquet, burns or intestinal manipulation the volume of fluid lost locally into the region of injury is expectedly large. The loss of such a proportion of the circulating blood volume would necessarily cause a marked impairment of the circulation, leading to shock. It still seems possible that, were the local loss restricted, significant loss elsewhere might be encountered. In experiments previously reported,^{17, 18} local fluid loss was prevented by the application of pressure by taping the traumatized extremities. Generalized circulatory impairment from reflex vasoconstriction was prevented in dogs by total sympathectomy or after recovery from spinal cord transection. Measurements of cardiac output demonstrated that the circulation was adequately maintained. Determinations of the total blood volume by the carbon monoxide method showed that a reduction of blood volume occurred as the animals went into shock following trauma, and the measured reduction in blood volume in these dogs which went into shock was greater than could be accounted for by the volume of fluid lost into the region of trauma. When shock failed to occur, the blood volume was higher than would have been expected from the volume of fluid lost. Fine, Seligman and Frank¹⁹ have observed that, following a severe burn, the decrease in plasma volume may be far greater than can be accounted for on the basis of the loss into the burned area. By the use of red cells containing radioactive iron, they were able to demonstrate a segregation or trapping of blood in the peripheral circulatory bed. Their experiments indicated that in shocked dogs some 20 to 30 per cent of the capillary blood volume in tissues was trapped in the peripheral bed. This "trapping" might have been produced by the decompensatory reactions of peripheral blood vessels described by Zweifach, Abell, Chambers and Clowes.²⁰ Page and Abell²¹ have observed this segregation of both red cells and plasma in the venules of

the dog's mesentery after severe hemorrhage Richards,⁴ on the other hand, reported that in only one case in the series of patients studied at the Bellevue Hospital was there evidence of "trapping" of blood in vessels with no active circulation. Fine and his associates¹⁹ concluded that "the progressive decline in shock is not due to a progressive fall in plasma volume but to a progressive fall in the volume of actively circulating plasma." In all these investigations on the site of the loss of plasma volume from the circulation, no effort was made to restrict the loss of fluid into the traumatized region. In the face of a major loss of blood and plasma into the area of injury the minor loss through other means might not be recognized. Only under the conditions of restricted local fluid loss would the loss into areas remote from trauma become discernible.

THE QUESTION OF INFECTION

The possibility that peripheral circulatory collapse which could not be accounted for on the basis of the amount of fluid lost into the area of injury might be due to the development of toxins from infection in the traumatized muscles must be considered. Pope and his associates²² have shown that the fluid from ischemic dog muscle is frequently toxic due to the presence of bacterial contamination. They concluded that "the element of bacterial infection and its consequences are factors that must be taken into consideration in physiologic experiments which continue for longer than a few hours." Freed and his colleagues²³ found that crushed muscle in dogs was always infected. Since the duration of the experiments which we performed was generally only three to four hours, the possibility that infection played a part is not likely but it may have been a significant factor.

FAILURE OF LOCAL FLUID LOSS TO ACCOUNT FOR SHOCK

Recent experiments by different groups of observers^{24 25 26 27} have cast doubt on the concept that local fluid loss after trauma or burns of the extremities is necessarily the cause of shock and death. Our own observations¹⁷ that shock could be produced by muscle trauma even with the restriction of local fluid loss are in keeping with these reports. Scott²⁸ found that of twenty-one dogs, after application of a pneumatic tourniquet sufficient to obstruct the venous return, twelve (57 per cent) died while the remaining nine made complete spontaneous recoveries. The average amount of fluid loss into the lower extremities in the two groups of animals was practically identical. He concluded that some other factor than local fluid loss must have been the primary cause of this type of shock. During the course of over 300 experiments on crushing injuries in dogs, Ricca and his associates²⁹ found that survival or death of the animal could not be predicted from the amount of swelling of the leg. By means of chemical analyses they demonstrated that the fluid which extravasates into the traumatized

extremity is mobilized from the rest of the tissues of the body. Only a portion of it is contributed by the loss of circulating plasma. Part of the protein content of this fluid came from the cell proteins of the traumatized tissues.

An additional observation which may be taken as evidence against the purely local fluid loss explanation of shock is the beneficial effect of cold, especially when applied locally to the traumatized area. Numerous investigators^{28 29 30 31 32} have demonstrated that either the onset of shock was delayed or ultimate survival was permitted by this local application of cold. Green and Bergeron³² found no significant difference between the measured edema of dogs kept in the laboratory and those kept in a cool environment following ischemic injuries of the extremities. However, the estimated maximum edema was greater in the former group. The beneficial effects of a cool environment were ascribed to a reduction in the metabolic activities of tissues, both local and general.

To summarize these findings: The volume of fluid lost into the region of trauma was frequently not sufficient to account for the decrease in plasma volume and there was frequently no correlation between the amount of local loss and the survival or death of the animal.

FAILURE OF REPLACEMENT THERAPY TO PREVENT SHOCK

The fact that replacement therapy is not always effective in preventing shock is another indication that simple loss of plasma or blood volume alone is not the sole explanation. Wilson and Roome³³ were the first to show that tourniquet shock in the dog could not be prevented by the administration of quantities of plasma greater in amount than the quantity of fluid lost into the injured area. It was only by combined amputation of the ischemic extremity and fluid replacement that recovery was assured. These experiments are open to the criticism that the element of infection was not taken into consideration. Ebert and Stead⁹ have shown that when peripheral circulatory collapse is due to infection it will not respond to increasing the blood volume but only to controlling the infection. This failure of the administration of blood to combat shock which is due to infection does not mean that restoration of the depleted blood volume which is simultaneously present will not be of help. Dunphy and Gibson³⁴ have shown that the replacement of plasma as it is being lost in experimental burns does much to ameliorate the pathological changes.

FAILURE OF REPLACEMENT THERAPY IN IRREVERSIBLE HEMORRHAGIC SHOCK

The inability of replacement therapy to prevent death from hemorrhagic shock, if the circulation has been seriously depressed for a considerable period of time, has been the subject of much fruitful research. Wiggers and Ingraham³⁵ have differentiated three major con-

ditions which may develop from uncomplicated hemorrhage of variable duration and intensity—simple hemorrhagic hypotension impending shock state and irreversible shock. After a trial of various agents for the treatment of hemorrhagic shock which was not responsive to the replacement of all shed blood Frank Seligman and Fine³⁶ came to the conclusion that "advanced shock constitutes a state of progressive deterioration which is not amenable to the types of therapy now available probably because fundamental biochemical changes have developed as a result of prolonged deficiency of capillary flow. These changes may result from injury predominantly involving one vital organ such as the liver or from widespread cellular damage." In further experiments they³⁷ demonstrated that the maintenance of an adequate blood flow through the liver was sufficient to prevent the development of irreversibility to transfusion in prolonged hemorrhagic shock. These findings appear to substantiate observations which we have previously reported³³ on the protection from the lethal effects of hemorrhage which was afforded dogs by preliminary sympathectomy. Whereas prolonged hypotension produced extensive necrosis of the liver lobules in normal dogs, after sympathectomy the animals could stand prolonged periods of hypotension without the development of liver necrosis. That the state of hypotension had been severe was shown by the symptoms of cerebral damage from anoxia shown by one of the sympathectomized dogs that recovered. Frank Seligman and Fine³⁷ noted similar cerebral symptoms in some of their "liver perfused" dogs and took this symptom as a criterion of the onset of

complete occlusion of the circulation for more than forty five minutes was demonstrated in the rat by Engel, Harrison and Long³⁹. They suggested that the irreversible stage of shock might be related to the failure of metabolic functions which they observed.

METABOLIC CHANGES

The observations on the significant part played by hepatic damage in the development of irreversible shock point toward some disturbance in cellular metabolism as the next field for research into the etiology of this condition. Stead and Warren⁴⁰ have brought out clearly the fact that this "generalized failure in cellular metabolism is a frequent cause of the shock syndrome"—however this failure be produced. Search for the significant disturbances has not as yet provided a clear answer as to the nature of the process involved but there have been numerous suggestive studies. The breakdown of the "sodium barrier" as a result of burns allowing large quantities of sodium to pass into the intracellular compartment and thus produce severe salt

depletion, has been reported by Fox and Keston.⁴¹ The benefits of salt replacement therapy to correct this disturbance have been emphasized by Rosenthal⁴² and by Hechter, Bergman and Prinzmetal.⁴³ However, in the treatment of salt depletion shock, Winkler, Danowski and Elkinton⁴⁴ found that colloid-containing solutions can exert a beneficial effect clearly beyond that due to the sodium chloride which they contain.

Considerable interest has been shown in the *enzymatic processes* in shock. Administration of cholinesterase produced remarkable results in the prevention of shock from intestinal manipulation, according to Schachter.⁴⁵ Recovery took place in sixteen out of eighteen dogs with this form of treatment, although all the control animals died. Metabolic studies by Davidson and his co-workers⁴⁶ on a group of patients with severe illnesses showed a "marked correlation between the degree of peripheral vascular failure and the profoundness of the biochemical abnormalities." The increase in the blood keto acids occurring in shock due to hemorrhage and the decrease following administration of thiamine with prolongation of survival times was reported by Govier and Greer.⁴⁷ The increase in tissue thiamine with corresponding decrease in cocarboxylase found in hemorrhagic shock by Alexander⁴⁸ suggested that thiamine might be of significance in the etiology of shock. Katzin and Warren,⁴⁹ however, were unable to demonstrate any correlation between thiamine deficiency and shock. Inhibition of amino acid oxidation in shock was found by De Turk and Greig⁵⁰ and this explanation was advanced to account for the increased concentration of amino acids noted in clinical cases by Lurje⁵¹ and in experimental shock by Engel, Winton and Long.⁵² The experiments of Russell, Long and Engel⁵³ showed that the increase in blood amino nitrogen was due, at least in part, to an increase in protein catabolism in the peripheral tissues. That this increase in concentration is not due to failure of deamination associated with liver injury was reported by Frank, Seligman and Fine.³⁷

The value of sodium succinate as a supplement to the use of dog plasma albumin in the treatment of shock due to the application of a tourniquet was reported by Mylon, Winternitz and de Sütö-Nagy,⁵⁴ but Frank, Seligman and Fine³⁶ were unable to demonstrate its usefulness in the treatment of shock produced in a similar way. Sodium succinate was found by Hechter, Bergman and Prinzmetal⁴³ to be no more effective in the treatment of shock due to burns than was sodium chloride.

Chemical changes in muscle due to anoxia and injury have also been of interest. Anoxia of muscle produces changes in the exchange of phosphates similar to those produced by exercise, according to Bollman and Flock.⁵⁵ With restoration of the circulation after periods of ischemia up to three hours, these changes are rapidly reversed. After occlusion of the circulation in the muscles for over three hours,

ditions which may develop from uncomplicated hemorrhage of variable duration and intensity—simple hemorrhagic hypotension, impending shock state, and irreversible shock. After a trial of various agents for the treatment of hemorrhagic shock which was not responsive to the replacement of all shed blood, Frank, Seligman and Fine³⁶ came to the conclusion that "advanced shock constitutes a state of progressive deterioration which is not amenable to the types of therapy now available, probably because fundamental biochemical changes have developed as a result of prolonged deficiency of capillary flow. These changes may result from injury predominantly involving one vital organ, such as the liver, or from widespread cellular damage." In further experiments they³⁷ demonstrated that the maintenance of an adequate blood flow through the liver was sufficient to prevent the development of irreversibility to transfusion in prolonged hemorrhagic shock. These findings appear to substantiate observations which we have previously reported³³ on the protection from the lethal effects of hemorrhage which was afforded dogs by prebiliary sympathectomy. Whereas prolonged hypotension produced extensive necrosis of the liver lobules in normal dogs, after sympathectomy the animals could stand prolonged periods of hypotension without the development of liver necrosis. That the state of hypotension had been severe was shown by the symptoms of cerebral damage from anoxia shown by one of the sympathectomized dogs that recovered. Frank, Seligman and Fine³⁷ noted similar cerebral symptoms in some of their "liver perfused" dogs and took this symptom as a criterion of the onset of irreversibility. Sympathectomy, in our previous experiments, by preventing reduction of circulation through vasoconstriction, might thus have allowed sufficient hepatic blood flow to prevent the consequences of irreparable liver injury. Irreversible damage to the liver by complete occlusion of the circulation for more than forty five minutes was demonstrated in the rat by Engel, Harrison and Long.³⁹ They suggested that the irreversible stage of shock might be related to the failure of metabolic functions which they observed.

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the chemical changes are not reversible and shock occurs when circulation is restored. They did not believe that these compounds played a significant role in the production of shock although Blum and Green⁵⁶ had previously identified adenosine triphosphate as the substance responsible for rapid death following intravenous injection of muscle extracts. There is the possibility that the production of tissue metabolism may contribute to the development of acidosis. This acidosis has long been recognized as a constant accompaniment of shock. The renal shut down which Green and Ingbar⁵⁷ have demonstrated is a factor which contributes to the irreversibility in hemorrhagic shock. Simply by the administration of sodium bicarbonate the mortality in experimental animals was lowered from 72 to 47 per cent.

Certain other metabolic changes have been noted such as the increased fragility of the red blood cells which was reported by Ruckenstein, Kitzin and Warren.⁵¹ This rise in fragility appeared to vary directly with the severity of the shock. Tagnon, Levenson, Davidson and Taylor⁵² have recently reported that the breakdown of body teolytic enzymatic process has been discovered by Lockwood⁵³ in experimental peritonitis.

CONCLUSIONS

Numerous mechanisms are involved in the production of shock. The simplest one and probably the most common is the failure of return flow of blood to the right heart with consequent reduction in cardiac output. This condition which usually results from hemorrhage or from the loss of blood or plasma into the area of injury, is readily and understandably amenable to replacement therapy provided that the circulatory depression is of short duration. If the contrary is true irreversible changes in the metabolism of cells throughout the body may be produced because of prolonged circulatory insufficiency.

In a second large group of cases the peripheral circulatory collapse results from metabolic disturbances in cells throughout the body such as that seen in overwhelming infections. The irreversible shock associated with prolonged circulatory insufficiency probably is essentially similar in its underlying mechanisms. Physiological and pathological studies on various enzymatic functions suggest that the liver is intimately concerned with the development of this stage of irreversibility. The researches of the past five years have clarified our understanding of the physiological processes involved in peripheral circulatory failure. There is no portion of the circulatory system which in the advanced stages of shock functions normally. Beyond the mechanisms responsible for the circulatory failure many interesting observations

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breakdown of foods to carbon dioxide and water and continues to be formed from body tissue when no food or fluids are taken

The normal person eliminates about 2500 cc of fluid daily through the (1) skin (sweat) (300 to 600 cc), (2) lungs (300 to 600 cc), (3) kidneys (600 to 1500 cc) and (4) intestines (100 cc) ^{3 9 10 13}

The normal intake and output of water may be changed either by a lack of preformed water or by an excessive loss of fluid Butler and Talbot¹⁰ have reviewed the intake and output of fluid and salts and have stressed the difference in the daily requirements of the infant,

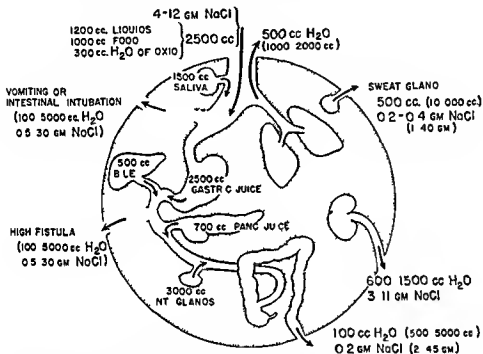


Fig 527—The normal and abnormal intake and output of fluid and salt (The possible abnormal loss of fluid and salt is shown in parentheses)

adolescent and adult This work points out the much greater caloric, water and even salt intake per kilogram of body weight in the infant as compared to the adult Such differences are important in treatment and should be taken into consideration when one is trying to determine what constitutes effective therapy in the infant or adult

It is easy to see that a marked diminution in the body water and the electrolytes will result if excessive perspiration, hyperventilation, vomiting drainage from a fistula (biliary, pancreatic or intestinal) or diarrhea occurs

GENERAL CONSIDERATIONS OF OSMOTIC EQUILIBRIA

In considering the above facts in detail, one immediately wonders what governs the location of, and the amount of fluid in the various

compartments. Since water is retained in the body in a rather constant amount it is necessary to consider the mechanisms by which this is accomplished.

The passage of fluids from one compartment into another is rapid and continuous¹⁴ and yet very little variation in the size and composition normally occurs. One of the main factors governing this is the osmotic pressure. The latter can be defined as the force by which a solution enclosed within a semipermeable membrane attracts water.

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organic or colloidal electrolytes (made up mostly of the protein fractions). These three types are not only important in maintaining the normal fluid distribution in the body but also in maintaining a proper acid base balance. This latter fact is significant since the body may give up electrolytes which are needed to retain water but it does so in order to maintain a relatively normal pH. However under most circumstances the osmotic pressure is maintained early in diseased states at the expense of some change in the acid base balance.

Organic Solutes of Small Molecular Size—Since the transfer of fluid across a membrane is effected mainly by the solutes which are impermeable to that membrane it naturally follows that the organic solutes of small molecular size are normally of little importance since they diffuse freely through the cell membranes. In certain diseased states total body water may be increased because of the accumulation of organic solutes; however it should be remembered that the location of such water in the body is not affected by the organic solutes since they diffuse freely throughout all of the body fluid compartments.

Because the inorganic electrolytes are present in relatively large amounts they are by far the most important factor in determining the total osmotic pressure of the body fluids and the quantity of water present. Before discussing these points in greater detail the significance of the colloids might be mentioned.

The Organic or Colloidal Electrolytes (Protein Fractions)—The various protein fractions do produce an osmotic effect but since they represent only a small part of the total^{15, 16} it will not be necessary to discuss each one. Of the proteins hemoglobin is the only one exerting more than 10 per cent of the total osmotic pressure in either the cells or plasma¹⁶. Since the hemoglobin concentration as we generally speak of it is dependent on both the amount of hemoglobin in the cell and the number of cells present the usual alterations encountered are of themselves of little importance as far as the quantity of body water is concerned. However Peters³ has pointed out that the presence of an anemia makes a hypoproteinemic animal or patient more susceptible to edema. It has also been emphasized^{17, 18, 19} that anoxic

states influence membrane permeability either through changes in the enzyme systems or other factors. Thus, hemoglobin may influence the quantity and distribution of the body water but such changes are only in a small part due to its osmotic effect.

The albumin fraction is of smaller molecular size than the rest of the plasma proteins,²⁰ and is important since it exerts 75 to 85 per cent of the total colloid osmotic pressure of the plasma proteins. Thus changes in the albumin fraction are especially significant. However, because of the relatively low concentration of the proteins, as compared to the inorganic electrolytes, the total quantity of body water is little influenced by them. Since the proteins are largely confined to the plasma and intracellular spaces, their effect is primarily from the standpoint of the transfer of fluid from one compartment to another. It is important to remember that changes solely in the colloid osmotic pressure rarely contribute to the abnormal distribution of body fluid. Such alterations are usually accompanied by changes in one or more of the following factors: the capillary permeability, filtration pressure, tissue tension and colloid osmotic pressure of the interstitial fluid. Thus, in the normal person the size of the individual cell and of the plasma volume is only partially dependent on the osmotic effect of protein. In certain abnormal states, plasma proteins, and especially the albumin fraction, pass rapidly through membranes to which they normally are almost completely impermeable.²¹⁻²² Under such circumstances the volume of the plasma is governed by other factors which will subsequently be considered in more detail.

Man and Peters²³ and Keys and Butt²⁴ present evidence to show that when an individual stands in the upright position there is a loss of fluid from the blood into the interstitial fluid compartment of the leg. This diminution of plasma water occurs due to a rise in the venous pressure. Keys and Butt²⁴ demonstrated that the loss of fluid caused a 24 per cent increase in the plasma protein concentration, and that such an increase was accompanied by a rise in the colloid osmotic pressure of 58 per cent. The total lipid, fatty acids and cholesterol content increased almost as much as the protein concentration. However, evidence is presented indicating that although the capillaries are impermeable to lipoids they exert little or no colloid osmotic effect. This experiment demonstrates the interrelationship of various factors (osmotic pressure, filtration pressure and so forth) and the importance of not one but several items in determining the distribution of body water.

The importance of a reduction of the plasma protein concentration and especially the plasma albumin has been demonstrated in experimental animals and in patients on a protein deficient diet.²⁵⁻³⁰ Clinically similar states do occur, but in this country such cases are usually complicated by a multiplicity of other factors (infection, generalized malnutrition including anemia, deficient vitamin intake). Since it is

felt that too little stress has been laid on these and other abnormalities (reduced cardiac output, changes in capillary permeability, filtration or venous pressure, and reduced kidney function) they are here emphasized so that a more complete understanding and hence a more rational therapy will be prescribed. The occurrence of malnutrition edema in surgical patients is fortunately relatively rare and the treatment in many instances is incomplete. Too often the patient is given plasma transfusions without regard to the existing anemia, hypovitaminosis or salt intake.

It has been shown³¹⁻³³ that in the cardiac patient edema results from a reduced renal blood flow and hence a reduction in the excretion of sodium. Such patients frequently exhibit a decrease in the plasma albumin concentration although in many instances the total circulating albumin may be normal. Improvement is not obtained by a restoration of the plasma albumin concentration to normal but as a rule a normal albumin concentration results when rational therapy is prescribed (restricted sodium intake, diuretics, proper diet). This point is emphasized since surgical patients exhibiting malnutrition edema can also be effectively treated by restricting salt and promoting a diuresis (diuretics, high protein diet) just as effectively as by giving plasma or albumin transfusions.³⁴ As a matter of fact, the results of the first method are often superior since frequently when plasma or albumin is employed the other details are overlooked. This does not mean that blood plasma concentrated plasma and albumin solutions cannot be employed under such circumstances with great benefit. This discussion is intended to emphasize that the lack of appreciation of the various ramifications of the problem in most instances accounts for the slow clinical recovery or the failures that sometimes occur.

Too often the readjustment of an abnormal fluid distribution is accomplished in a manner that is not conducive to best results. Frequently we have encountered cases in which dietitians have been instructed to provide a low salt diet while at the same time amino acid solutions containing a moderate amount of salt are being employed. In other instances diuretics are given without regard to the salt intake. The importance of an understanding of the physiological problems thus becomes evident.

The Inorganic Electrolytes—Some of the inorganic electrolytes are far more important than others because they are present in larger amounts. Thus, in order to avoid confusion little will be said about calcium and magnesium since their solute concentration is so low that their osmotic effect is practically negligible. It might be stated however, that while calcium exerts only a small portion of the total osmotic pressure, its presence in normal amounts is important since the concentration of calcium is one of the factors governing the permeability of membranes.³⁵ Fortunately, significant changes in the plasma calcium level are not frequently encountered clinically and

are largely confined to abnormal endocrine or prolonged nutritional states

The inorganic electrolytes are either anions (acid) or cations (base). Since two or more anions are present in both the intracellular and extracellular fluids and since an increase or decrease of one is accompanied by a reciprocal fall or rise of the other, the anions have little effect on the total osmotic pressure.¹⁻³ For example, if the extracellular fluid chloride content decreases, it is accompanied by an increase in bicarbonate or in some instances in the ketone bodies. Intracellular changes in the chloride and bicarbonate concentrations occur normally, depending on the state of oxygenation of the blood.³⁰ Abnormally, persistent changes in concentration of these anions may be found, and Guest and Rapoport³⁷ have pointed out that the concentration of organic acid soluble phosphorus in the blood cell increases in the presence of pyloric obstruction and decreases in other diseased states.

Therefore, from the standpoint of the osmotic pressure and the quantity of body fluid present the cations, sodium and potassium, are the most important. In the normal individual sodium is largely confined to the extracellular space and potassium to the intracellular region.¹⁻¹¹ Because of this it has been felt¹⁻¹¹ that these two ions play the dominant role in determining the quantity of water in each of the two main fluid compartments.

In discussing the transfer of ions through cell surfaces and membranes, Krogh³³ points out that evidence has accumulated which shows that living muscle fibers are definitely permeable to both sodium and potassium and under certain circumstances significant changes in the intracellular concentration of these ions occur. He believes that energy expended by the cell causes the absorption of some ions and its resistance to others. If both sodium and potassium are freely permeable, the fact that they are present in different concentration leads one to believe that the passage of ions through a membrane is accomplished largely by passive means (Donnan equilibrium), and that the prevention of such a transfer is dependent on the active resistance by the cell or its membrane.

In abnormal states it has been pointed out⁵⁻³⁹⁻⁴¹ that when potassium leaves the cell sodium may on occasion enter. Butler, McKhann and Gamble⁴² demonstrated, in patients with dehydration resulting from diarrhea, that a large quantity of water and potassium was withdrawn from the intracellular compartment. Since intracellular salts and water leave the cell during such a state it should be remembered that a potassium depletion occurs which is not corrected by the usual parenteral fluid therapy. Interesting studies by Darrow⁴³ have recently emphasized the importance of the administration of potassium to infants with diarrhea. Gowan and Darrow⁴⁴ report a remarkable clinical improvement in infants suffering from diarrhea and a highly sig-

nificant reduction in the mortality rate when potassium therapy was employed. In a previous publication, Darrow⁶ discussed the possible significance of this type of therapy and stressed the dangers which might result from its use. He also pointed out that when intracellular sodium enters the extracellular fluid there is a resulting alkalosis and when extracellular sodium enters the cell an acidosis tends to occur. It seems highly probable that future work will clarify the potassium need in other diseased states.

In the various body fluids there is frequently a marked difference in the ionic pattern but it should be remembered that regardless of the chemical difference the total osmotic pressure is approximately the same except in those fluids which are excreted onto a relatively impermeable epithelial surface (saliva and perspiration).¹⁻³

DEHYDRATION AND OVERHYDRATION

In considering dehydrated states it is well to emphasize that decreases in water or salt may occur. As a rule both are lost, but in many instances a decrease in one or the other predominates. Since the clinical picture varies in the two different and distinct types of dehydration, it is necessary to emphasize the importance of each.⁹⁻⁴³⁻⁴⁸

Dehydration Due to Deficient Fluid Intake.—McCance⁴⁹ has studied the changes occurring in volunteer subjects on an adequate diet but a deficient fluid intake. He points out that they showed a fall in body weight shortly after the individual stopped taking water. A peculiar pinched gray appearance of the face developed, with the patient appearing worse than he actually felt. Symptoms of thirst and an inability to swallow in the normal fashion developed early. There was little change in the solute concentration of the various blood constituents during the first two to four days. Subsequently some increase in the nitrogenous products in the blood occurred and if the condition progressed a slow rise continued. The inorganic electrolyte concentration decreased fairly late when dehydration had existed for several days. The cellular and protein components showed only moderate changes. During the first two days the greatest loss was in the extracellular fluid compartment, but later the loss in absolute amounts, was predominantly intracellular. In proportion to the respective size of the two compartments, however, the percentage of decrease of each was about equal. The daily volume of urine decreased and was largely dependent on the protein catabolized and the nitrogen excreted. The changes McCance found in the extracellular and intracellular fluid volumes during water deprivation were somewhat similar to the experimental findings of Hopper, Elkinton and Winkler.⁴³ They demonstrated that a slightly greater amount of intracellular fluid was lost in dogs deprived of water. Their figures show, however, that the percentage of change from normal is greater in the extracellular fluid volume.

Dehydration Due to Salt Deficiency.—In dehydrated states in which salt, or water and salt, are lost the symptoms are more pronounced than when only a depletion of water occurs^{9 45-48} There is a loss of weight, weakness, mental apathy, anorexia and hypotension The extracellular fluid volume shows a much higher percentage of decrease than does the intracellular fluid When such a condition develops rapidly, prostration is marked, and hypotension, hemoconcentration and an increase in the blood cellular and protein constituents are important features⁴⁶⁻⁴⁸ Thirst and oliguria are not as pronounced as in salt deficiencies and when the available water is also reduced a decrease in the volume of urine gradually occurs If, on the other hand, fluids are permitted ad libitum and the salt loss is more gradual the clinical picture is somewhat different

Experiments⁵⁰ have shown that the quantity of water consumed is dependent on the amount of salt and nitrogen taken or the amount of these constituents to be excreted Thus the quantity of urine is governed to a great extent by the salt and protein intake Work by Allen and Cope⁵¹ stress the effect on the kidney (and blood pressure in hypertensive animals) of anesthesia and a high protein, salt or water intake They point out that the kidney decreases in size during etherization (presumably due to a reduction in renal blood flow) and increases when a high protein, salt or water intake is given They believe that the increase in size resulting from a continued water and salt overload is largely due to hyperemia and that the enlargement from protein is accompanied by less temporary but a more permanent increase (actual renal hypertrophy) An appreciation of the findings in the aforementioned experiments^{50 51} thus help to clarify the influence of certain dietary products and their effect on renal function and body water

Carbohydrates in Preventing Dehydration.—Because the intake of sufficient calories or an adequate amount of carbohydrate reduces the protein catabolism in the presence of a deficient protein intake, it in turn decreases the rapidity with which the water is lost It has been shown in human volunteer subjects⁵²⁻⁵⁴ that in states of water, food and salt deprivation, the taking of as little as 100 gm of carbohydrate daily will decrease the rapidity with which dehydration occurs Naturally one would expect this since the ingestion of carbohydrate reduces the catabolism of protein, and therefore, the kidneys need less water to eliminate the nitrogenous waste products Winkler, Danowski, Elkinton and Peters⁵⁴ state that "anti dehydrating effect of carbohydrate early in deprivation is in part the result of the water produced through its oxidation and in part the result of the protein-sparing effect" They also point out that "It is possible that with progressive ketosis, the excretion of ketone bodies assumes a greater role in the production of dehydration"

In states of normal hydration, on the other hand, dextrose has no

apparent effect on the rate in which fluid or salt is excreted. In the report by Campbell, Iob and Berry⁵⁵ they attempt to draw a parallelism between their experiments and those of Gamble and Butler.⁵ The former workers pointed out that in postoperative patients infused with a solution of dextrose and saline the dextrose did not influence the rate of electrolyte retention. They go on to state that this finding "is contrary to the hypothesis of Gamble and Butler."

It must be pointed out that the experiments of Gamble and Butler were of an entirely different nature. The latter workers were dealing with individuals on a restricted caloric water and salt regimen for six days while the studies of the former group were conducted over a much shorter period of time (thirty hours) and in postoperative cases that received normal to excessive intakes of water and salt. The experiments of Campbell and his associates did not disprove the hypothesis of Gamble and Butler.

Further Notes on Salt Deficiency—In the volunteer subjects studied by McCance⁴⁹ the salt deficiencies were produced over a period of ten to eleven days. This work demonstrated deficiencies of extracellular salt and water of greater magnitude than occurred in short term experiments. When water was consumed ad libitum cramps were noted which resembled those seen in water intoxication or so called "miner

a peculiar se
type of fruit

washing the mouth with salt water. Anorexia and nausea were prominent symptoms and fatigue and exhaustion occurred. The pulse rate was not changed although the amplitude was diminished and the plasma and blood volumes were apparently decreased. The kidneys continued to function fairly well although McCance reported⁴⁹ that the rate of urine excretion did not increase rapidly as it does in individuals who are in a normal state of hydration^{54, 57} following the ingestion of large amounts of water. Others^{58, 59} have observed that even in the presence of dehydration a relatively normal diuresis will often occur when water is administered. Salt free liquids will provide fluid for the kidneys but it should be remembered that the body requires both water and salt to correct a state of dehydration.

McCance⁴⁹ noted that the symptoms, chemical changes and the failure of a diuresis to occur following the administration of water resembled that seen in Addison's disease.^{59, 60} A rise in the cell count, hemoglobin concentration and plasma protein level also took place although these changes were not as marked as those seen in the more acute experiments. A definite negative nitrogen balance was noted and the kidneys gradually lost their efficiency for excreting the nitrogenous waste products.

When a temporary alkalosis was produced in the aforementioned experiments by hyperventilating, it caused a considerable reduction in

the volume of urine and hence in the elimination of sodium, urea and chloride McCance excluded the possibility that the increased exercise from hyperventilating (hence a diversion of the blood flowing through the kidneys) was the cause of this decrease. He concluded that the kidney must, therefore, be seriously hampered when an alkalosis combined with a salt deficiency exists. Since such a state frequently occurs when pyloric obstruction is present, the high blood urea in such a condition is due largely to these changes. The experimental findings of Adolph⁶¹ show that a low oxygen or high carbon dioxide tension likewise greatly retards the rate of urine formation.

The work of McQuarrie and Whipple,⁶² Haden and Orr⁶³ and Gomori and Podhradsky⁶⁴ demonstrate that the rising blood urea is primarily due to a reduced urine flow but is also somewhat dependent on an excessive nitrogen breakdown. It has been pointed out³⁴ that the kidneys do not return to normal immediately upon the correction of dehydration and the excessive nitrogen catabolism. The subject was well discussed by Marriott⁶⁵ in an earlier review.

Renal Insufficiency during Water Deprivation.—It is well known that renal insufficiency takes place during periods of water deprivation and it is believed that there are numerous reasons why this occurs. It often is not evident early but eventually a prerenal azotemia will occur if the dehydrated state progresses. The renal insufficiency is due to hypotension, a decrease in the available water and an increase in the osmotic pressure and in the viscosity of the blood. Lauson, Bradley and Cournand⁶⁶ have shown that the renal blood flow and pressure may decrease in traumatized and shocked subjects prior to the occurrence of a generalized drop in blood pressure, hence, a reduction in the rate of glomerular filtration in traumatized or dehydrated individuals is usually a premonitory sign of a generalized peripheral vascular collapse. It is also possible that during salt deficiencies or dehydration the kidney cells may undergo certain changes so that the organ does not function efficiently.

It has been recently reemphasized³⁴ that an individual recovering from dehydration or shock may show a rising blood urea in the presence of a fairly adequate fluid intake and apparently normal urine volume. In such states the administration of large amounts of water (4000 to 6000 cc. in adults) should be carried out so that the patient's normal urine volume can be doubled or trebled. Such a procedure should be quite safe if the proper type of fluid is administered and the kidneys are able to excrete water. The kidneys lose their power to concentrate urine properly after a period of dehydration as a result of a reduction in glomerular filtration and failure of the tubules to reabsorb the usual quantity of water.

Following the relief of obstructions in the urinary tract the kidneys may also be unable to concentrate normally, so such patients frequently need to excrete 1500 to 2500 cc. of urine per day in order to maintain a

normal blood urea or nonprotein nitrogen concentration. In patients with bleeding of the gastrointestinal tract the high blood urea concentrations are almost entirely due to a reduction in the renal blood flow and an increased nitrogen catabolism. The blood is often vomited or passed in the stool before it can be digested and absorbed; hence the protein from it contributes little to the rising blood urea level.^{66a}

Summary of Clinical Effects of Dehydration—It seems important to emphasize that dehydration may exhibit itself in several different ways. The symptoms which occur are dependent on not only the rapidity with which dehydration takes place but also upon the relative loss of water and salt. When the change is rapid an increase in the viscosity of the blood takes place. This apparently results from a concentration of both the protein and cellular elements. In more chronic states of dehydration the viscosity is not greatly altered and the circulatory system has a better opportunity to compensate for the diminution in the blood volume. Clinically, this latter fact is probably significant since cases of malnutrition and chronic recurrent hemorrhages show deficiencies which would often lead to shock or death if produced over a period of hours rather than days or weeks. Since the reduction in blood volume is not accompanied by significant changes in the blood viscosity the cardiac filling and output are not greatly affected and the individual compensates better under the circumstances than would be possible in an acute decrease in the blood volume.

Experimental studies⁶⁷⁻⁷⁰ have shown that the total amount of body water may be little affected and yet serious states produced by an abnormal distribution of water. Studies by Davis⁷¹ and Winkler and his associates⁷² show that a hypertonicity of the extracellular fluid by attracting water and thus depleting other areas of the body may cause many untoward symptoms and even death.

Coller and his co-workers⁷³ have shown that when large amounts of isotonic saline are administered the excretion of water is greater than that of salt. The extracellular electrolyte concentration is temporarily increased and under such circumstances it is believed that equilibrium is restored by withdrawing water from the intracellular phase.

Since studies by Sunderman⁷⁴ indicate that in diabetic acidosis the greatest deficiency of fluid is in the intracellular compartment, it would appear that the administration of isotonic salt solutions would correct the extracellular fluid deficit but might lead to a further serious depletion of intracellular water. It also seems from the work of Atchley and his associates⁷⁵ that since a large amount of intracellular fluid is lost in diabetic acidosis (and they demonstrated a marked excretion of intracellular constituents [K, PO_4 , SO_4 and N]) such patients also show a potassium depletion.

These circumstances may explain why the patient with severe diabetic acidosis sometimes temporarily responds only to succumb twelve to twenty-four hours later. Further studies should clarify these

problems but it does seem evident that such patients may have sufficient fluid therapy, but since on occasion it is the wrong type, the resulting changes lead to death

Water Intoxication.—McCance's experiments¹⁹ on salt deficiency indicate that such individuals are more susceptible to water intoxication since they are depleted of electrolytes and cannot eliminate water in the normal fashion. Since few institutions have a wide variety of solutions available for exact and proper treatment, one is largely dependent on the patient's kidneys to eliminate the undesirable salts or water. While such seriously ill patients constitute only a small minority of patients needing medical care, a further reduction in the mortality rate of this select group will be accomplished only by improving kidney function or by the more judicious use of the various fluids.

An oliguria may result in some instances after the excessive administration of saline²⁴ ²⁶ 77 and the return of kidney function is accomplished, not by a hit or miss administration of fluids, but by the proper selection of a fluid which will correct the difficulty and cause a resumption of kidney function.

Oliguria following water administration occurs when the individual has severe kidney disease or is in, or nearing, a state of water intoxication, or may result from abnormal endocrine activity.

Since water intoxication may be encountered clinically and since it has been thought that such a state may contribute to epileptiform attacks,⁷⁸ toxemias of burns,⁷⁹ ⁸⁰ and abnormal states of pregnancy,⁸¹ it seems worth while reviewing the symptoms which are present. In 1923 Rowntree⁸² emphasized that headache, dizziness, restlessness, vomiting, cramps, asthenia, incoordination, urinary frequency, diarrhea, tremors, ataxia, convulsions, frothing, stupor and coma occurred. It is rare that all these symptoms are present. Thus since a serious state may occur under a variety of circumstances, it becomes necessary to know, if the body electrolytes are depleted, the amount and type of fluid consumed and the response of the kidneys to the administered fluids.

Renal Function as a Consideration in Treatment.—Normally, wide fluctuations in body water and in the acid base balance are prevented because of the ability of the kidney to eliminate excessive amounts of water or electrolytes and in time of need to excrete a urine with a high specific gravity, which has few of the desired solutes. Thus, it becomes necessary when treating patients to know if the circulatory system and the kidneys are functioning properly. In certain instances the kidney may be losing large amounts of albumin (nephrosis) and in other instances excessive sodium excretion may occur. More recently it has been reemphasized⁸ ³¹⁻³⁴ ⁷⁷ ⁸³ that the kidney may at times lose its ability to excrete certain inorganic electrolytes (sodium and chloride), although anuria is not present. Thus, when apparently normal amounts of sodium are given the body tends

TABLE 2 -A STUDY DEMONSTRATING THE DISCREPANCY BETWEEN THE PLASMA PROTEIN CONCENTRATION AND TOTAL CIRCULATING PLASMA PROTEIN IN A PATIENT IN THE NORMAL AND IN THE DEHYDRATED STATE

State of Patient	Total Plasma Volume (cc)	Plasma Protein Conc (gm/100 cc)	Total Circulat Plasma Protein (gm)	Plasma Protein Conc (per cent of normal)	Total Circulat. Protein (per cent of normal)
During period of dehydration	1920	7.00	135	100	72
Control	2640	7.00	185	100	100

to accumulate it because of the kidneys' inability to excrete it. Earlier it was shown that in certain instances there is an ability on the part of the kidneys to excrete salt and water when pneumonia⁸⁴ and other diseased or abnormal states^{32 33 85-90} exist

Tests of Certain Blood Constituents as Indices of a Patient's State of Hydration.—States of overhydration or dehydration cannot be quantitatively estimated by alterations in the solute concentrations. This fact cannot be emphasized too strongly since during the past eight years there have been numerous articles^{15 91-103} advocating the use of tests of certain blood constituents (hematocrit, plasma, protein concentration, chloride level, specific gravity of whole blood and

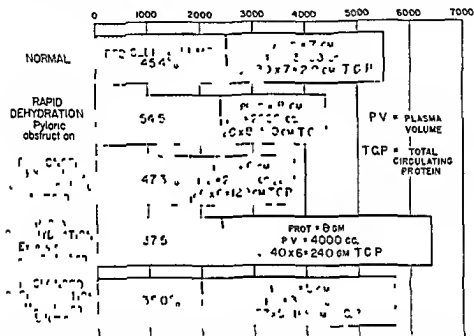


Fig 528 —The failure of the plasma protein concentration to denote the need for therapy, or the amount of total circulating plasma protein present. (The cross-hatched area equals the red cell mass, and the open area of the bar the extent of the plasma volume)

plasma, and others) as an index to a patient's state of hydration, or as a guide in the treatment of shock

Many of the reasons why the various blood levels cannot be employed will be discussed later. Table 2 shows how the plasma protein concentration may be deceptive. It can be seen that even though the plasma protein concentrations are equal, the plasma volumes and the total amount of circulating plasma proteins are different. Thus the protein concentration gives no indication of the total amount of circulating protein. The failure of changes in the various blood constituents to determine the state of dehydration can be more clearly seen in Figure 528. This figure shows that a wide variety of red

cell and protein concentrations may occur where the total red cell volumes and plasma volumes are increased or decreased. Dieckmann and Wegner¹⁰⁴ present studies which demonstrate that during a normal pregnancy the anemia is due in many instances to hydremia. They point out that often the cellular elements are increased, but in spite of this there is a reduction of the hemoglobin, erythrocyte count and hematocrit reading as a result of dilution.

In the experimental animals with a pancreatic fistula or in patients with a high intestinal, biliary or pancreatic fistula the plasma volume shows a progressive drop, the chlorides are usually normal or high, and the hematocrit and plasma protein concentration may be normal or increased. Since under the circumstances the chloride level does not mirror the diminution in the plasma volume, it cannot be used as a guide to the state of hydration. On the other hand, animals with cardiac compression (constrictive pericarditis) sometimes show chloride levels which are high when the animals are edematous,¹⁰⁵ and low plasma or serum chloride concentrations are seen in overhydrated, burned or cardiac patients or in cases with malnutrition edema. Low values occur in dehydrated patients with pyloric obstruction and other intestinal disorders.

McIver and Gamble¹⁰⁶ stated in 1928 that "Hepatic duct bile and fluid derived from the intestinal mucosa contain approximately the same amount of fixed base and chloride ion as does plasma. Loss of this fluid will cause a reduction of the volume of the blood plasma and of interstitial fluid but should not alter the plasma chloride (or bicarbonate) concentrations." Thus, they concluded that "A point of great practical importance to be derived from this is that it is entirely incorrect to regard the plasma chloride concentration as an index of the degree of dehydration and of the extent to which replacement by salt solution is required. Because of the fairly wide deviation of the normal hematocrit reading¹⁰⁷ and the withdrawal or destruction of cells and plasma proteins in shock¹⁰⁸⁻¹¹⁰ and dehydration⁹⁵ the hematocrit, specific gravity of whole blood and plasma, red cell count and hemoglobin concentration may also be misleading.

Malnutrition, the state of kidney function, the treatment given, and the type of fluid lost play important roles in determining the plasma and whole blood concentrations. It should be remembered, therefore, that the solute concentration can be normal, high or low when the total amount of body water is increased, normal or decreased. Thus, the body solute concentrations (red cells, protein, chloride, and so on) may not mirror the amount of such solutes present, or indicate the amount and type of fluid needed. In certain instances, especially during acute alterations, some solutes may show directional changes, but rarely can they be employed to show quantitative alterations. In many instances a physician regarding an obviously dehydrated patient remarks that the patient's blood chemistry has remained normal. As the previous discussion points out, this may not be the case and the

misconception occurs because only concentrations are considered without studying or estimating changes in fluid volume. Alterations in the volume of fluid can be fairly accurately estimated from the history, the clinical course and the physical examination. Thus clinical rules are not a substitute for a physiological understanding of the problem and sound clinical judgment.

THE TRANSFER OF FLUIDS ACROSS CAPILLARY MEMBRANES

The transfer of fluid across the capillary membrane is an important factor and is necessary to carry foodstuffs to the cells and waste products away. The importance of the protein fraction in this exchange was first recognized by Starling¹⁵ in 1895. The present concept^{3, 7, 8, 18, 111, 112} recognizes two principal forces: (1) capillary blood pressure (filtration pressure), and (2) the colloid osmotic pressure of the blood. There are also two secondary forces: (1) tissue tension and (2) colloid osmotic pressure of the interstitial fluid. Thus, the fluid in the circulating blood tends to pass back into the capillaries because of the tissue tension and the intracapillary colloid osmotic pressure. We are most familiar with the effects of a lowered plasma protein (particularly the albumin, because it exerts approximately seven times as much osmotic pressure as globulin). When the total protein falls to 5.5 (plus or minus 0.3 gm) the colloid osmotic pressure is low and interstitial fluid usually tends to accumulate, provided water and salt are present.¹¹³

The accumulation of edema can result from any one of the following causes, or as usually happens, a combination of several:

- 1 Low plasma protein (especially the albumin fraction)
- 2 Increased venous pressure (increased hydrostatic or filtration pressure) due to high blood pressure, stasis or a venous block. Cardiac failure, compression of the heart or partial or complete venous occlusion due to external pressure or internal abnormalities (such as thrombosis or tumor invasion) should be considered.
- 3 Failure of the kidneys to excrete normal amounts of water and inorganic electrolytes.
- 4 The overadministration of salt and water or an endocrine dysfunction causing a retention of sodium or water.
- 5 Increased capillary permeability (anoxia, histamine).
- 6 Increased osmotic pressure of the interstitial fluid (This is often accompanied by an increased capillary permeability which may result from stasis or anoxia and permits the colloids to leak out).
- 7 Obstruction of lymphatics.

FACTORS GOVERNING THE EXCHANGE OF FLUIDS IN DISEASED CONDITIONS

While four factors largely govern the exchanges of fluids in the normal individual, diseased conditions introduce additional problems.

Vascular obstruction or stasis, change in the viscosity of the blood and alteration in the capillary permeability often overshadow the normal factors regulating the transfer of fluid, protein and salts

Warren and Stead³¹ have presented an excellent review of the causes of cardiac edema. They have stressed the importance of sodium retention in such cases and the more recent studies of Merrill³³ give confirmation to their views. Lyons, Avery and Jacobson¹¹⁴ have shown that significant changes in the plasma volume of normal individuals may result by the overadministration of sodium-containing fluids. The results of these three studies show the importance of salt and water in the production of edema and also demonstrate^{31 114} that a marked rise in the total circulating plasma proteins can occur when a fairly normal state of nutrition exists. Experimental studies¹¹⁵ have demonstrated that protein is mobilized apparently from, or by way of, the lymphatics. If a healthy dog was bled one-fourth of its calculated blood volume, the protein level would return to normal in eighteen to twenty-four hours. However, if the thoracic duct was ligated and a similar bleeding performed it might take as long as nine to fourteen days before the control protein concentration was restored. Studies by Pride and his associates¹¹⁶ demonstrated that hypoproteinemic animals do mobilize protein but at a somewhat slower rate than normal animals.

From the above data, one wonders if the plasma proteins are as essential in maintaining the plasma volume in the diseased state as we previously believed. In animal experiments⁷⁰ it has been shown that the osmotic pressure of the increased plasma protein concentration did not cause a plasma volume restoration during a period of five to six days, in the face of extracellular dehydration. However, the plasma volume returned to normal when salt was administered. Landis and associates¹¹⁷ recently well reviewed the problem and point out that it is important to remember that numerous factors govern the size of the various body fluid compartments and that all factors are important, no one having preference.

Since it is of smaller molecular weight, albumin is lost from the vascular system in abnormal states in larger amounts than globulin. Thus, in cases in which anoxia, high venous pressure or venous stasis occur, albumin is present in relatively large amounts in edema or ascitic fluid.^{83 87 105 118} (Examples of this occur in nephritis, cardiac failure, cardiac compression, cirrhosis and in edematous areas resulting from trauma.)

In evaluating a patient's state of hydration, it is therefore necessary to obtain a careful history (duration of illness, food and fluid intake, appetite, weight loss, thirst, amount and frequency of vomiting, diarrhea, blood loss), and also to make a careful physical examination (paying special attention to the loss of turgor, sunken eyes, presence of edema). The clinical course should then be carefully followed

(water intake and output recorded, type and make up of fluid administered or lost, electrolytes present, specific gravity of urine, response to therapy noted)

Chemical analysis (plasma carbon dioxide, chloride and protein concentration, hematocrit, red blood cell count and hemoglobin) can be extremely helpful if they are employed properly and interpreted in the light of the clinical findings but they alone will not give a complete picture

CLINICAL APPLICATION OF FLUID BALANCE PROBLEMS

Before discussing specific disorders, a few fundamental principles should be stressed. First, it should be pointed out that previously it was thought that the interstitial fluid acted as a reservoir to maintain the plasma volume near normal.^{1 119 120} Gamble and McIver¹²⁰ thus postulated that the plasma volume was kept within normal limits at the expense of interstitial water. They felt that only terminally, when fairly large amounts of interstitial fluid were lost, was a decrease in the circulating blood volume noted. Mellors, Muntwyler, Mautz and Abbott¹²¹ showed that this was not necessarily the case. They pointed out that the interstitial fluid was not an elastic compartment but when dehydration occurred a diminution in the total extracellular phase (plasma volume and interstitial volume) took place. This does not mean that the interstitial fluid does not supply water and salts to the plasma volume as Gamble^{1 119} suggested, but does show that the plasma volume is not sustained at a normal level until late in the process of disease.

Secondly, it has been shown⁷⁰ that if the plasma protein concentration rises rapidly (as it often will in acute dehydration), or if concentrated albumin is injected,¹²² the osmotic pressure although greatly increased does not draw fluid back into the blood stream unless the proper electrolytes and water are present. For example, Table 3 shows studies¹²³ in normal dogs in which 100 to 120 cc per kilogram of a 5 per cent dextrose solution was injected intraperitoneally.

It can be seen that when such a solution is injected intraperitoneally (or subcutaneously), even though it is isotonic with plasma, marked alterations in the plasma volume and electrolyte concentration result. This occurs because glucose does not diffuse across the peritoneal membrane (into the extracellular fluid) as rapidly as the solutes (sodium bicarbonate, urea, chloride, etc.) present in the extracellular fluid, diffuse into the abdominal cavity. Hence while small amounts of glucose are passing into the body, these solutes diffuse into the peritoneal fluid. This results in a temporary drop in the concentration of the solutes of the extracellular fluid, causing it to become hypotonic as compared to the intracellular fluid. Since the solutes present within the cell (potassium, phosphates, etc.) do not, as a rule, pass out through the cell membrane, osmotic equilibrium is largely restored by

BLE 3 --THE EFFECT OF INJECTING 100 TO 120 CC OF A 5 PER CENT DEXTROSE SOLUTION INTRAPERITONEALLY

Dog No	Time after Intra-peritoneal Injection	Hematocrit	Plasma Protein Conc. (gm per 100 cc)	Plasma Chloride Level (m eq per liter)	Ascetic Fluid		
					Urea Nitrogen (mg per 100 cc)	Chloride (M eq per liter)	CO ₂ Content
1	Control 4 hours	50.0	6.72	113.8	0	0	0
		73.0	12.07	86.2	14.1	75.8	23.6
2	Control 2 hours 4 hours 6 $\frac{2}{3}$ hours	49.2	6.12	110.0	0	0	0
		62.4	8.54	93.8	4.81	44.5	—
		68.9	9.46	89.9	7.05	59.3	—
		78.9	10.44	83.1	9.20	68.1	25.2

water shifting into the cell. When this occurs there is an intracellular overhydration with a resulting extracellular fluid dehydration.

If 2000 cc. of 5 per cent dextrose solution were injected intraperitoneally in a 20 kilogram dog and four hours later 2000 cc. of fluid removed from the abdominal cavity, the alterations seen in Table 3 would be present without any change in the total body water (merely a shift of water from the extracellular to the intracellular compartment). The opposite phenomenon (a depletion of intracellular water with extracellular overhydration) may occur when fairly large amounts of salt are given intravenously either in hypertonic or isotonic solutions, also with death resulting. Thus, clinically 5 per cent dextrose in distilled water should not be given subcutaneously or intraperitoneally unless it is definitely indicated or unless one appreciates the changes that result. This solution has undoubtedly been employed many times in such a fashion without serious consequences. This is because relatively small amounts of fluid were injected, thus producing changes that were not severe. The real danger occurs in patients who have an extracellular dehydration or an intracellular fluid compartment which is overhydrated.

Thirdly, it should be emphasized that in certain diseased states, changes in the blood chemistry occur which are not necessarily produced by the disorder but rather result from the treatment or because of the inability of the patient's kidneys to excrete properly.

Burns.—If burned animals^{79 80 114 115} or patients⁸³ are given water in fairly large amounts, a dilution of the blood concentrations occurs because the consumed fluid does not contain inorganic electrolytes or protein. Thus a definite fall in the plasma protein and chloride levels would be noted. Similarly, if plasma or a salt solution containing the inorganic ions present in plasma is employed, little change in the sodium, chloride or bicarbonate concentrations occur. When treatment is carried out with a physiologic salt solution, water or plasma, the protein concentration usually shows some decrease by the third to fifth day^{80 83}. Since this may occur, although to a lesser extent, following the administration of large amounts of protein it is thought to be due in a great part to dilution⁸³. This view is supported by studies^{31 114 125} which show a fall in the plasma protein concentration while there is actually an increase in the total circulating plasma proteins. Some of the rapid falls in protein concentration reported^{126 127} following major surgery are likewise thought to be due in part to dilution.⁸

Again it should be emphasized that kidney function plays an extremely important role in fluid balance. In dehydration there may be insufficient body water available to carry out the nitrogenous waste products, hence the blood urea nitrogen rises (extrarenal or prerenal azotemia), but if adequate water and normal kidney function are present an elevation of the blood urea nitrogen is not seen.³⁴

Selye¹⁷⁸ and Harkins¹²⁹ reported that the blood urea nitrogen or non protein nitrogen level of the blood usually is elevated in patients with thermal burns. Actually in our experience⁸³ this rarely occurred because in most of the burned patients studied an apparently normal kidney function and an adequate amount of water for the elimination of waste products were present. This emphasizes the fact that often the chemical changes which are described for a certain disease may result from the treatment given or from lack of therapy. In a few very seriously burned individuals who appeared to be normally hydrated or overhydrated it has been observed⁸³ that a liter of water taken orally does not produce a change in the per minute rate of urine excretion as it would in a normal person. In this respect the findings resemble those referred to previously in this paper in the experiments of McCance⁴⁹ and in patients with Addison's disease.⁵⁹ The studies of Gaunt¹³⁰ indicate that this may occur because of deficient adrenal cortical function since adrenalectomized rats show "a prompt diminution in the diuretic response to water and a susceptibility to water intoxication. Similar changes are observed in hyperthyroid animals¹³ show a susceptibility to water intoxication but this is also thought to be due to adrenal cortical deficiency."

A rise of the plasma chloride level above normal usually denotes renal impairment or prerenal azotemia. Such a rise may occur when a patient has an external pancreatic fistula because of a greater loss of sodium than chloride and occurs only if there is a lack of available water. It has also been emphasized that fluctuations in electrolyte concentrations in diseased states often fail to denote the excessive administration or the need for various inorganic salts.

Debilitating Disease—In patients with carcinoma of the stomach there has usually been a fairly long period (two to eight months) of weight loss and vomiting prior to the time they are seen. Thus in almost every instance they are dehydrated and malnourished.¹³³ Because of the inadequate food intake anemia and hypoproteinemia are almost always present. This latter fact may not be evident by the red count, hemoglobin, hematocrit and plasma protein concentration since dehydration has masked the drop in the concentration of these constituents.¹³³ In such cases the history would be a better means of determining the extent of malnutrition.

Patients with other debilitating diseases (stenosis of the pylorus due to ulcer carcinoma of the esophagus etc.) will show similar alterations.¹³³ It is not necessary to make volume studies in all such cases because it can be assumed that patients with such diseases exhibiting marked weight loss show this phenomenon. The history, duration and magnitude of symptoms and examination of the patient help to give one a good idea of the severity of the change present. In fact since the expected normal plasma volume cannot be accurately estimated¹⁰⁷

the determined value unless it was markedly abnormal would be of little significance as a guide to therapy. Thus, on prescribing treatment it is first advisable to estimate the approximate extent of the nutritional deficiency present. Such deficiencies can be corrected by an adequate dietary intake (oral when possible and parenteral if necessary) and more rapidly by an adequate diet plus blood transfusions. In the event that the state of nutrition is not improved prior to operation such a patient is susceptible to complications which might prevent his recovery.¹³³ The dangers of giving such patients too much salt has been repeatedly emphasized,^{8 13 34 65 73 76 77 127 133 134 135} and thus it is important for the physician always to specify carefully the amount of sodium containing solutions to be used. Unfortunately, this is not always done and the patient may receive 9 to 27 gm of sodium chloride daily.

Hemorrhage.—More acute deficiencies are encountered with hemorrhage. For example, patients with bleeding peptic ulcers rapidly deplete their body stores of not only red cells but protein as well.¹³³ These patients also do poorly after operation if this condition is not corrected. Saline solution is not well tolerated and often leads to peripheral edema as well as pulmonary edema with subsequent pneumonia. A 5 to 10 per cent dextrose solution in distilled water given by a slow intravenous drip is advocated after adequate blood has been administered. The low plasma protein concentration and the inability of the kidney to excrete sodium following shock, prolonged anesthesia and operative intervention make the administration of a solution of normal saline to such patients dangerous.

Patients with bleeding peptic ulcers that will not respond to medical therapy and require operation to stop the hemorrhage should be given large amounts of whole blood (2500 to 4500 cc) and minimal amounts of sodium chloride until the hypoproteinemia and anemia are corrected. When such therapy is carefully employed the mortality rate for gastrectomy should approximate that found in nonbleeding cases.

Excessive Sweating.—In warm weather¹³⁰ or when a patient has a high fever¹³⁷ it is well to remember that dehydration may result from excessive perspiration. Considerable water may be lost and the sodium content of the body may likewise be depleted. While some sodium is lost in sweat, the greatest loss under such circumstances is generally through the kidneys. Since the electrolyte concentrations in perspiration are relatively low, a greater loss of water occurs.¹³⁶ If this is not corrected, osmotic equilibrium is restored by the elimination of inorganic electrolytes in the urine. Thus, when sweating is excessive, water or a hypotonic salt solution should be given. The administration of concentrated salt solution should be employed only if water intoxication has occurred. In fact, it is not uncommon to see individuals who in trying to prevent an excessive salt loss by taking salt tablets

develop nausea diarrhea and intestinal cramps. Such condition results from a lack of sufficient water.

The importance of the above discussion may be questioned but it points out that when excessive perspiration occurs the untreated patient develops a deficiency of water and salt with a greater loss of water. If the deficiency is mild the taking of salt alone produces a further water loss. This results in diarrhea or vomiting if the salt is not absorbed from the gastrointestinal tract and a further water loss through the kidneys if it is absorbed. If the deficiency is marked the administration of large amounts of water once it has developed causes water intoxication. It seems advisable to stress these points since patients who are hyperventilating or have fever and other diseases complicating the state of fluid balance can be better handled if these facts are kept in mind.

Hypertension—The studies of Grollman and Harrison¹³⁸ and their associates¹³⁹ discuss the effect of extremely low salt diets on hypertensive animals and patients. It would seem probable that the reduction in blood pressure was accompanied by a fall in the blood volume (dehydration). Such treatment in the hypertensive patient without edema would seem to be of little permanent value and would leave the individual with only a small margin of safety in the event that vomiting, diarrhea or excessive sweating occurred.

Intestinal Obstruction—In patients with low simple intestinal obstruction shock and death in most instances have been thought to be due to the absorption of some toxic product.¹⁴⁰⁻¹⁴⁴ While recent studies¹⁴⁵⁻¹⁴⁶ show that bacteria or bacterial toxins may also cause death it should be remembered that dehydration alone can account for the aforementioned alterations. Obstruction due to a closed loop or intestinal strangulation usually results in an ischemia, necrosis and ulceration with systemic penetration of bacteria or their toxins. The studies of Dragstedt and his associates¹⁴³⁻¹⁴⁴ first proposed this view and showed that both distention which resulted in an impairment to the circulation and bacteria were important. The experimental studies of Harper and Blain¹⁴⁵ and Blum and Kennedy¹⁴⁶ substantiate this view and also show the value of penicillin in reducing the mortality rate in experimental closed loop obstructions or in prolonging the survival time of animals with strangulated obstruction.

Death due to dehydration was formerly thought to occur in high intestinal (pyloric) obstruction but not in the majority of cases with low obstructions.¹⁴¹⁻¹⁴² Volume studies¹⁴⁷⁻¹⁴⁸ show that marked dehydration may result from any level of obstruction and here again the changes in the hematocrit, chloride and protein concentration may not be indicative of the extent of the red cell protein water and salt deficiency.

Gendel and Fine¹⁴⁷ and other workers¹⁵⁰⁻¹⁵⁵ have shown that distended bowel per se definitely produces undesirable systemic changes.

as well as a rapid reduction in the plasma volume. It not only causes an accelerated loss of extracellular fluid but as Gatch and Culbertson¹⁵⁵ have shown may lead to ischemia of the part when the intraluminal intestinal pressure exceeds that of the capillaries. Harper and Lemmer¹⁵⁶ have substantiated the earlier view^{143 144 157} that distention in itself does not necessarily lead to death but will when the bacteria which normally inhabit the intestinal tract invade the intestinal wall (They believe this occurs following necrosis and ulceration of the intestinal mucosa and the bacteria or their toxic products cause an undesirable systemic effect). It seems probable that varying degrees of a potassium deficiency may also occur in patients with intestinal obstruction. Thus death may result from various factors all of which should be corrected if the treatment is to be successful.

Peters^{157 158} has stressed the importance of omitting everything by mouth when employing gastric suction or high intestinal intubation. Many of these patients want to drink, but if permitted to, they merely wash out electrolytes and thus make the control of such cases much more complex. Peters^{157 158} and Foster¹⁵⁹ point out that gastric drainage decreases to almost nothing if the oral intake is stopped. On the other hand, Penberthy, Irvin and Tenery¹⁶⁰ have stressed the importance of early feeding when the double lumen long intestinal tube is employed. This unquestionably should be done when possible but probably not until the tube has moved down into the low jejunum or ileum. Thus in most instances since this cannot be accomplished short of several days, it is of little value in obstruction of the small bowel but is largely advantageous in patients with obstruction of the colon and in some patients with paralytic ileus.

Death may occur in patients with intestinal obstruction solely from a reduction of body water and salts but other factors are of at least equal importance in closed loop or strangulated obstruction. Although dehydration in this latter type of case may not be the main cause for concern it should never be neglected. It seems important here to stress the fact that a fairly large number of cases of intestinal obstruction *due to adhesions* often start as simple obstruction only later to develop into strangulated obstruction.¹⁶¹ This is due to a segment of bowel linking or herniating under an adhesive band. In the latter type or when distention in the presence of simple obstruction progresses, often some impairment to the blood supply eventually occurs.

Intestinal Fistula—High intestinal fistulas create one of the most troublesome complications for a surgeon to treat. Such disorders are now relatively uncommon because of the improved preoperative and postoperative care. Hartzell¹⁶² has advocated a rubber cup to plug the orifice and prevent the loss of intestinal juices. Such a method should be of great benefit to the patient provided that an obstruction distal to the fistula or infection is not present. Parenteral feedings, transfusions and adequate water and electrolyte restoration are

essential. Marked dehydration may occur if external drainage is present, and here again the solute concentrations may be quite misleading. The hematocrit, protein, chloride and carbon dioxide concentrations may give no indication of impending disaster. The sodium concentration may be normal or low and again may not indicate the true state of hydration. Volume determinations might show the deficit but as a rule should be unnecessary since the proper treatment can be carried out by following carefully the clinical course of the patient and by the judicious use of parenteral electrolyte solutions and blood. Parenteral feedings should be employed when the fistula is high and an attempt made to pass a long tube past the point of the fistula. If this can be accomplished, feedings distal to the site of external drainage can be administered. During the time that high intestinal suction is being employed nothing should be given orally. If external drainage continues and the tube cannot be made to pass beyond the point of the fistula in the duodenum or upper jejunum, a jejunostomy should be done for feeding purposes.

Trauma and Shock.—Since injured patients may exhibit changes in kidney function (crush syndrome) and since the more frequent use of whole blood in larger amounts may result in a higher incidence of the deposition of blood pigments in the renal tubules, the preventive and therapeutic measures for this abnormality will be briefly discussed. Recent studies indicate^{163 164} that the deposition of blood pigments in the kidneys occurs when an oliguria and aciduria exist. Thus the correction or prevention of shock and the administration of fluids which will promote a good urinary flow are of prime importance. The administration of hypotonic electrolyte solutions is usually indicated, the amount and type of salts administered being dependent upon the patient's condition and acid base balance. The administration of sodium bicarbonate, lactate or citrate may be helpful in conjunction with other forms of treatment but the dangers and ineffectiveness of alkalization alone have been pointed out by Corcoran and Page.¹⁶⁵ Once uremia occurs the correction of the condition is often difficult, hence therapy should be directed primarily at its prevention.

Recently several articles^{123 163 166} have appeared which have reviewed the previous literature on the subject and indicate that peritoneal lavage or irrigation may provide a means for correcting acute renal failure. The ultimate success of such treatment is dependent not only on the selection of the proper fluid and understanding of the fluid balance and acid base problems, but upon the fact that irreversible changes in the kidney have not occurred.

The importance of fluid and electrolyte changes in many states of shock and the use of sodium containing solutions in the treatment of such conditions has recently received considerable attention.^{39 40 80 83 124 167 173}

It is true that such therapy is of little value, as Fine, Frank and

Seligman¹⁷⁴ have pointed out, when a state of irreversible shock is present. However, most civilian patients are seen before such a state exists. The proper selection of parenteral fluids, if given in adequate amounts, is therefore usually adequate to correct the difficulties. When malnutrition exists or an internal or external hemorrhage has occurred, whole blood in adequate amounts should, of course, accompany the judicious use of a physiologic electrolyte solution.

Because a large amount of experimental and clinical evidence has accumulated and since other studies^{21, 22} indicate that plasma proteins are rapidly lost in peripheral vascular collapse, it seems evident that in many instances when such states exist a physiologic salt solution is as good as plasma.

As Darrow¹⁷⁵ has pointed out, hemoconcentration is rarely a contraindication to the use of whole blood. High red counts, hemoglobin concentrations and cell volumes are frequently found when some decrease in the total red cell mass has occurred. Therefore, the effect of giving blood which, because of the citrate present usually has a cell volume of less than 40 per cent, is not that of increasing hemoconcentration but of decreasing it. In instances in which plasma is being lost rapidly (burns), the prevention of further hemoconcentration can be accomplished by the administration of the proper salt solution in conjunction with blood.

Recent studies²⁰ seem to indicate that blood viscosity would be affected as much by changes in the protein concentration as in the cell volume. In fact, it would seem from this work that the viscosity would be increased to a greater extent when the fibrinogen and globulin concentrations rose than when the albumin level or red cell count increased. Other studies^{83, 172, 176, 177} show that the prevention of hypotension is accomplished by increasing the tissue tension in states of peripheral vascular collapse or impending shock. The administration of plasma protein only temporarily increases the plasma volume since the protein leaves the vascular system relatively rapidly. In dehydration the administration of albumin solutions are of little value unless sufficient salt and water are present.^{122, 178} In burns since treatment with a hypotonic electrolyte solution has been employed, the severely burned patients (40 to 60 per cent of the body burned) have shown a maintenance of a normal blood pressure and pulse. The urine volumes during the first twenty-four to forty-eight hours have been two to five times greater than those seen in the previously plasma treated group. The importance of providing shocked patients with adequate amounts of red blood cells has been stressed and it has been pointed out that plasma may increase the circulating blood volume but may not correct the state of anoxia.¹⁷⁹

It is hoped that the previous discussion will not leave the impression that blood chemical studies are useless but rather that their interpretation should be based on a sound physiological knowledge.

Comment.—Since improvement in kidney function is important in the final outcome of many serious surgical disorders, it is felt that the response of the kidneys to treatment (the periodic recording of the rate of urine flow and specific gravity) should be observed more frequently. In other words the attempt to stereotype therapy or outline it for twelve to forty-eight hours in advance should be abandoned in the seriously ill surgical patient. The importance of frequent study of the patient rather than reliance solely upon the various blood concentrations cannot be overemphasized. Obviously, the careful interpretation and evaluation of all the findings (history, physical examination, clinical course, laboratory reports) give the best results and one without the others leads to confusion.

Evidence also seems to be accumulating to show that the hematocrit, hemoglobin, red blood count and the whole blood specific gravity are not good indices of the state and extent of an existing deficiency or of the amount and type of therapy to be employed.^{5 8 83 84 133 147 150} Although some recent reports continue to advocate such methods for controlling postoperative patients and those in shock, there are few studies which provide evidence in support of these clinical rules which were for the most part based on theoretical work.

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SOME ASPECTS OF NUTRITION IN MAN

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THE importance that can be attached to the success of research on the relation of nutrition to disease should not prevent the development of other pathologic hypotheses and theories of its genesis and cure. With each discovery of a new essential dietary component the search begins for an explanation of its function and at a later date the determination of its usefulness in human nutrition. It must be admitted that progress in the latter field of investigation has been rapid in the last years.

In the process of obtaining information upon essential nutrients a procedure that can be called one of oversimplification has been employed. The physiologic test object has usually been the growing animal, for growth requires materials both for maintenance and tissue accretion. The dietaries have been limited, if possible, only to purified food constituents. By the use of such tools many chemical substances have been detected and identified as necessary for proper growth and even for maintenance of life itself.

Our knowledge of how they perform their functions is far from complete. The metabolic functions of many of the vitamins are known though the mode of action of some of them is still obscure. In many instances chemical entities that appear to have a definite role in the dietaries of experimental animals have yet to be classed as essential elements in the dietaries of humans.

It is more than certain that nutritional defects are at least a part of the etiologic basis of many of the common illnesses. Yet this is only a conviction without satisfactory proof. For example, tuberculosis and other infective diseases increase when the nutritional status of a population is decreased greatly. So many factors are concerned that the collection of unequivocal proof will require many detailed studies by future investigators.

IMPORTANCE OF THE PROTEINS

There is widespread recognition of the value of adequate protein nutrition in the care of many types of medical and surgical patients. In a sense this is a fulfillment of the meaning of the word protein, i e., of *first importance*.

Proteins are the main nitrogenous constituent of all animal and plant cells. They are found in both protoplasm and nuclei of cells and

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are the major constituent of muscle and glandular tissues. The functional integrity of each unit depends largely upon the presence of specific proteins, enzymes, hormones and antibodies. The proteins are composed chiefly of amino acids which occur in varying amounts in different proteins. Specificity in the protein is determined not alone by the amounts, but by the manner of combination and spatial relationships of the component amino acids.

Some twenty two amino acids have been characterized as constituents of proteins. Not all occur in every protein, and not all need to be present in the diet for continued well being.

The main function of protein in the diet is to provide nitrogen and sulfur in the form of amino acids for processes of life in which they are required. This includes growth, maintenance, reproduction, lactation, repair and convalescence. In recent years the interest in proteins has been shifting from proteins *per se* to their constituent amino acids and the functions that these latter fulfill within the organism. With the development of improved analytical methods more has been learned of the variations in amino acid composition of proteins and their bearing upon the nutritional adequacy of the various proteins. Similarly improved methods of analysis have increased the knowledge of the metabolic fate of individual amino acids. It may be stated that at present one of the most urgent problems is to determine the amino acid requirements (protein) for man in health and disease.

ESSENTIAL AMINO ACIDS

Through the investigations of Hopkins, Osborne and Mendel and particularly Rose¹ certain amino acids were found to be essential parts of the diets of growing rats. Those amino acids that were found to be indispensable for the growth of the rat were lysine, tryptophane, leucine, isoleucine, threonine, methionine, valine, histidine and arginine. These have also been called "essential" amino acids, i.e. the growing animal was unable either to synthesize them or the rate of synthesis was too slow to satisfy the needs for growth.

These results have been confirmed in the dog and later in the mouse² and approximate qualitative requirements of the various amino acids for maximum rate of growth were determined.

These amino acids for growth may be called essential. The maintenance of nitrogen equilibrium requires only a small amount of these amino acids for growth may be maintained by supplying the following amino acids: threonine, isoleucine, leucine, tryptophane, valine and methionine.

The requirements of amino acids for nitrogen equilibrium during short feeding periods in normal adult male humans has been studied by Rose and co-workers.⁴ The twelve amino acids found nonessential for rats and dogs are likewise not required by the human. With the

exclusion of valine, methionine, threonine, leucine, isoleucine or phenylalanine from the diet a negative nitrogen balance developed promptly Histidine withdrawal did not affect nitrogen equilibrium and, therefore, was nonessential for nitrogen equilibrium Tryptophane likewise has been found necessary for nitrogen equilibrium while the requirements for arginine and lysine are very low

EFFECTS OF SINGLE AMINO ACID DEFICIENCIES

Attempts have been made to determine the specific effects induced by single amino acid deficiencies One of the difficulties in assessing the effects is the decreasing appetite often produced by the deficiency Paired feeding controls reduce this difficulty somewhat but may not be the whole answer Harris, Neuberger and Singer⁵ have produced a cessation of growth and a hypoproteinemia in young rats by means of lysine deficiency The body weight remained fairly constant, but there appeared to be a general inhibition of protein formation, with marked muscle wasting decreased subcutaneous fat and reduced calcification of the bones

Albanese and associates⁶ have studied the effects of deficiencies in man of tryptophane, lysine, arginine, methionine cystine and histidine

Studies of the effects of varying the quantities of sulfur amino acids in the diets of experimental animals have been most productive in showing their multifaceted role in the physiologic economy of the animal This is particularly true of methionine Jackson and Block⁷ showed that methionine was essential for the growth of young rats Its central position derives from the fact that it can enter into a variety of metabolic processes The sulfur of methionine can be used for the synthesis of cystine The methyl in the S methyl group can be used in the synthesis of choline and creatinine⁸ In fact the concept of the biologically labile methyl group in playing a role in nitrogen sulfur, fat and carbohydrate metabolism has been emphasized by du Vigneaud⁹

Thus in the production of dietary fatty livers, choline was early shown by Best to play a predominant role in preventing the accumulation of fat Further work indicated that increasing the dietary proteins likewise produced a lipotropic effect Tucker and Eckstein¹⁰ presented evidence that the net lipotropic effect of casein could be explained solely on the balance between the opposing influence of cystine and methionine More recent work suggests that the many divergent conclusions upon the relative effects of different proteins and of cystine and methionine may be associated with the fact that the lipotropic action of methionine is markedly affected by abundance or lack of other essential amino acids When these are plentiful, the lipotropic effect of methionine will be maximal

That other dietary constituents may have a marked effect on the development of nutritional fatty livers is demonstrated by the reports of

the influence of the lack of various B vitamins in the production of this condition. These observations are summarized in a review on the significance of choline as a dietary factor.¹² When so many factors are known to affect nutritional fatty livers, it is not surprising that widely divergent results have been reported, and when any one of these dietary essentials is tested clinically, it must be kept in mind that a variety of results may be expected. Indiscriminate testing with an accumulation of negative results may lead to the discrediting of an otherwise valuable therapeutic agent.

NUTRITIONAL FACTORS IN HEPATIC LESIONS

Two hepatic lesions have been described as a result of dietary deficiencies in experimental animals: one a cirrhosis resembling in many aspects Liennec's cirrhosis in man, the other a massive necrosis involving much of the parenchymal tissue and often accompanied by hemorrhage. Numerous investigations have been made showing that liver damage and cirrhosis may result from deficiencies of the vitamin B complex or of protein. In general, the dietaries used have the capacity of causing a fatty infiltration of the liver. Only two of several reports will be cited. Himsworth and Glynn¹³ tend to support the thesis that the two types of lesions can be differentiated both on etiologic and anatomic considerations. In contrast to the usual latent period on favorable diets of forty to sixty days for necrosis, diffuse fibrosis was not obtained in less than one hundred and fifty days. They found that the determining factor in the incidence of necrosis was the protein fraction of the diet and more specially that methionine played the predominant role in the prevention of necrosis. Gyorgy¹⁴ presented evidence that those factors which lead to the production of fatty livers cause considerable hepatic damage. He also showed that experimental dietary hepatic damage is frequently combined in the same animal with pathologic changes in the kidney, ranging from bilateral hemorrhagic cortical necrosis to the milder diffuse cortical nephrosis. In the diets employed, the B vitamins remained constant while the protein, fat, cystine, methionine, and choline were varied. By lowering the casein content of the diet, damage to the liver was observed with greater regularity. The lipotropic effect of casein was believed to be due to methionine. Supplements of cystine increased the incidence of cirrhosis, but many animals still developed necrosis. Choline plus cystine or *dl* methionine alone proved highly effective in preventing dietary injury to the liver.

This knowledge gained from animal experiments was quickly tested in patients with cirrhosis. Diets high in protein, carbohydrate, B vitamins, and low in fat were given together with choline or methionine. Thus Russakoff and Blumberg¹⁵ studied ten cases of cirrhosis in man for periods up to two years. Definite clinical improvement occurred in seven of the cases when choline was added to the above diet. Other

reports^{16 17} may be cited to indicate that choline exhibited a beneficial supplementary effect

Methionine has been used extensively in a variety of conditions in which abnormal liver metabolism is present. The original impetus for its use derived from the report of Miller and Whipple¹⁸ that methionine is the most active amino acid in decreasing hepatic susceptibility to toxic substances. It has been used in experimental studies of chloroform, mapharsen, dichlorethane, carbon tetrachloride, arsphenamine and selenium. The role of methionine in the development of experimental hepatic necrosis and cirrhosis likewise stimulated clinical investigation of its therapeutic value.

Beattie and Marshall¹⁹ in a study of four hundred and fifty cases of infective hepatitis and "postarsphenamine jaundice" indicated a marked beneficial effect of methionine and casein digests, particularly in the gravely ill patient. However, Peters and associates,²⁰ reporting on one hundred and fifty similar cases reported that both cystine and methionine had a significant but not a remarkable effect on the course of the jaundice while casein had no effect. Eddy²¹ studied the clinical course of thirty cases of toxic hepatitis following exposure to trinitro toluene. Ten cases had severe liver damage and about one third were fatal. There were no fatal cases among those treated with methionine. Although no controls were used, clinical and laboratory data before and after methionine therapy indicated general improvement.

What is needed are more detailed and controlled studies to determine the exact usefulness of these suggested therapeutic agents. Such agents may well prove to be successful adjuncts but should not be used to the exclusion of giving as complete a diet as possible. To discuss the liver in relation to protein metabolism would require a monograph by itself. The above short discussion upon the effects of dietary supplements in affecting the susceptibility of this organ to a variety of toxic agents indicates the magnitude of the problem. It becomes certain that all these dietary factors affecting the liver metabolism are not acting independently one of another. There will be a continual interplay of forces whose net effect will vary with the balance of the nutrient essentials present.

REQUIREMENTS OF PROTEIN IN THE NORMAL DIET

Our thinking upon the relative requirements of any of these constituents, particularly amino acids, is based largely upon the growth requirements of animals and short term balance experiments in normal adults. The determination of the requirements of the separate components in various abnormal states is urgently needed. Until that time an effort can be made to supply the known essentials in more than adequate amounts.

During World War I the nutritional importance of protein was expressed by the remark attributed to Professor Starling, "If you look

after the calories, protein will look after itself." This is broadly true when total protein is concerned. In the currently recommended allowances of the National Research Council² for protein for normal humans, protein furnishes approximately 64 per cent of the calories to be ingested by the adult man at vigorous work and 139 per cent of the calories to be consumed during the third trimester of pregnancy. The additional recommendation is that at least one third to one half of this protein be of animal origin while the remainder may come from vegetable protein. This is in recognition of the fact that proteins from animal sources are more complete in the "essential" amino acids, for in practice any dietary of natural foodstuffs will furnish approximately 10 to 12 per cent of the calories from protein. Therefore, variety in the choice of food is good nutritional practice, for there is better opportunity to obtain a more balanced intake of the various essentials.

It is of interest to consider what is known of the biological values of the common food proteins, as evidenced by their capacity to cause growth in adolescent animals, and also to correlate these observations with their known amino acid composition. Mitchell and Block³ have made such a correlation for twenty eight proteins. Whole egg protein is taken as a standard protein mixture, which is completely digestible and utilizable, and for comparative purposes is assumed to have the optimum mixture of the known essential amino acids. The percentage deviation of the content of each essential amino acid from the corresponding content in whole egg protein is computed. The limiting amino acids thus indicated agree well with the reported feeding experiments with one or two exceptions, for which partial explanations can be advanced. The limiting amino acid varies in different proteins. Their order of frequency is lysine, 9 instances; methionine, 5; cystine and methionine, 5; isoleucine, 3, and tryptophane, 1. This does not mean that only 1 amino acid is deficient in a single protein for in many instances other essentials will also be low at the same time; e.g., tryptophane is listed as the limiting amino acid in gelatin and it is well known that it is also deficient in other amino acids (cystine, methionine, valine).

While these observations may appear academic in the practical problem of the nutrition of the patient, they must be considered in interpreting results of comparative feeding regimens. It should make us cautious in assaying the successes or failures recorded under various dietary regimens. Success in one instance may depend upon the (unsuspected) relative abundance of other nutritionally important essentials and failure in other reported instances may be due to the relative paucity of substances not under direct test.

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CIRCULATORY PHYSIOLOGY: THE ADJUSTMENT TO BLOOD LOSS AND POSTURAL CHANGES

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THE circulatory adjustments that occur in man as a result of hemorrhage or of postural change involve physiological mechanisms which have direct diagnostic and therapeutic applications for the surgeon. No attempt will be made here to deal with other aspects of circulatory physiology.

The chief function of the circulation is the maintenance of an adequate blood supply to all parts of the body at the same time. This could be accomplished by requiring the heart at all times to pump to *each* organ the maximal amount of blood that would ever be needed by it under any condition. Such a plan would require a much larger blood volume than man has. It would also require at all times cardiac activity greater than that in the severest burst of muscular activity, for though the muscles receive their maximal attainable blood flow at this time, other organs are not simultaneously at peak activity.

Actually the human circulatory system works with a relatively small blood volume and demands the use of only a small percentage of the total cardiac work capacity. While this design conserves cardiac energy, it requires a complicated regulatory system which must be able to provide adequate amounts of blood to the organs that most need it. This is accomplished in large part by the sympathetic nervous system.

ROLE OF THE SYMPATHETIC NERVOUS SYSTEM IN VASOMOTOR ACTIVITY

The sympathetic nervous system includes fibers whose stimulation leads to an acceleration and augmentation of the heart beat, and to secretion of adrenalin. It also includes a large number of vasoconstrictor fibers. The latter are not distributed evenly throughout the body. It is important to note that the organs which have the most abundant vasoconstrictor innervation (the skin, kidneys, spleen and gastrointestinal tract) are those which are either nonessential to life

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or those whose activity can be dispensed with for a few hours. At the other extreme are those organs (brain, heart, lungs) which are so vital that interruption of blood flow to them for only a few minutes would be disastrous, the vessels of these organs have few or no sympathetic vasoconstrictor nerves.

Cannon has provided an excellent explanation of this arrangement. The sympathetic nervous system functions as a whole. When thrown into activity by such fundamental emergencies as the need for "flight or defense" or by hemorrhage, all parts of the sympathetic system become hyperactive. Cardiac contractions are augmented and the arterioles are constricted in proportion to the degree of their sympathetic innervation. Thus the vessels in the "nonessential" organs will constrict markedly, those in the "essential" organs will not. The consequence of this is that blood is shunted from nonessential to essential organs and the blood flow to the cardiac, cerebral and pulmonary vessels can be maintained in times of emergency. Skeletal muscles, needed for flight and defense, occupy an intermediate position and have only moderate sympathetic nerve supply, consequently diffuse sympathetic activity should lead to maintenance of muscle blood flow. The sympathetic control of the venous side of the circulation is still a matter for further research. It is probable that, in times of emergency, the large veins contract and shunt their blood to the vital organs.

What determines whether the sympathetic nervous system shall be active or inactive? Sympathetic activity involves an outflow of nerve impulses through a vasomotor center, the most sensitive portion of which is located in the medulla, though it is continued into the spinal cord as well. The activity of this center may be altered (1) by chemical factors acting directly upon it, or (2) by reflexes reaching it from peripheral portions of the body.

1 Chemical Control of the Vasomotor Center—This is achieved largely by the tension or pressure of carbon dioxide acting upon the cells of the vasomotor center. Inhalation of carbon dioxide increases the activity of this center, the inhalation of 7.5 to 10 per cent carbon dioxide in normal man can be expected to increase blood pressure by approximately 30/20 mm. of mercury and to increase the pulse rate by 16 beats per minute*. Conversely, decrease in arterial carbon dioxide, as by voluntary or mechanical hyperventilation, should decrease the activity of the vasomotor center. However, this decrease in function becomes apparent only in the anesthetized individual, for only in this instance does a decrease in arterial carbon dioxide tension lead to hypotension. In normal man, hyperventilation does not lower blood pressure, probably because, under normal conditions, other more delicate regulatory factors maintain the circulation.

* Since this is the brain for 50 per cent as a

the vessels of about 30 to

The part played by carbon dioxide in the control of the normal human circulation appears to be a minor one. One exception to this generalization is in asphyxia. Another exception is found in hemorrhage shock or fainting in these instances blood flow through the medullary centers may be so reduced that it is not sufficient to carry away the carbon dioxide formed within these medullary cells. This "piling up" of metabolic carbon dioxide may stimulate these cells to greater activity.

2 Reflex Control of the Vasomotor Center—The most important reflexes acting upon the vasomotor center are those set up in the carotid sinus and aortic arch in response to changes in arterial blood pressure. These receptors do not respond to drugs or to chemical changes in the blood (as do the chemical receptors in the adjacent carotid and aortic bodies) they react only to changes in blood pressure within the aortic arch and carotid bifurcations. These pressure receptors are the "pressure stats" of the circulatory system and act similarly to thermostats in a heating system. If the house temperature rises above a desired level the thermostat keeps it down by shutting off or by restraining the central heating plant. The action of such a thermostat is wholly inhibitory.

Correspondingly if the blood pressure in the aortic arch or carotid bifurcation rises above normal the pressure receptors act reflexly to restrain the vasomotor center and so lower blood pressure to normal levels. This is accomplished by lessening the degree of vasoconstriction and cardio acceleration. On the other hand if arterial blood pressure falls as in hemorrhage or shock the pressure receptors no longer restrain the vasomotor center and the sympathetic nervous system can become maximally active.

The pressure receptors of man are probably more sensitive than those of the common laboratory animals. Procedures which lower blood pressure consistently and markedly in anesthetized dogs (such as intravenous nitrites or curare) lead to little or no hypotension in normal man. This compensatory mechanism is so delicate in man that the slightest tendency toward hypotension leads to instantaneous augmentation of cardiac activity and peripheral vasoconstriction which tend to stabilize the arterial pressure.*

Many other circulatory reflexes are known (chemoreceptor cold pain proprioceptor axone venous pressure and nutritive reflexes) and each of these fills a definite need. However omission of these from further discussion is intentional since they play little part in the circulatory adjustments to hemorrhage or positional change.

The status of the circulation at any particular time is not entirely the result of direct or reflex actions upon the vasomotor center. Many substances can act entirely peripherally to dilate or constrict vessels.

* As will be seen later this reflex mechanism is occasionally superseded by a stronger influence probably arising in the cerebral cortex.

and so alter blood pressure and blood distribution. Epinephrine injected intravenously can produce all the effects of sympathetic stimulation even when the vasomotor center is no longer effective (depressed by trauma, anesthesia or anoxia or its peripheral connections disrupted by spinal anesthesia or by sympathectomy). Ephedrine, amphetamine, desoxyephedrine and the like act similarly in varying degrees. Histamine, acetylcholine, nitrites, carbon dioxide and anoxemia act directly upon the arterioles as vasodilators; the latter two in direct opposition to their central action through the vasomotor center. Temperature changes also affect vessels directly in addition to their central actions.

PRACTICAL APPLICATIONS OF PHYSIOLOGICAL PRINCIPLES

1 Hemorrhage.—Surgeons generally believe that hemorrhage can be detected early and simply by noting a drop in arterial blood pressure and a rise in pulse rate.

This is not usually true of small or even moderate sized hemorrhages and is not always true even in hemorrhages of considerable extent. Meek and Eyster³ showed in 1921 that when hemorrhage is produced experimentally in dogs, blood pressure may not fall until moderate amounts of blood are withdrawn. This is the result of compensatory mechanisms brought into play. As blood pressure starts to fall, the change in carotid sinus and aortic arch pressure receptors activity leads to a stimulation (i.e., less inhibition) of the vasomotor and cardiac centers, with consequent augmentation in peripheral resistance and cardiac activity which may now be able to maintain arterial pressure. Beyond a critical point, even maximal vasoconstriction and cardiac acceleration cannot maintain blood pressure. Before this point, blood loss changes arterial pressure very little; beyond this point, even small blood loss may lead to a precipitous fall in pressure. This critical quantity in normal man appears to be about 1000 to 1200 cc. Of eleven subjects bled these amounts by Shoenkin and his co-workers,⁴ six showed very slight immediate changes in blood pressure (average was a decrease in systolic pressure of 5 mm. and an increase in diastolic pressure of 4 mm. of mercury), in these the circulatory adjustments were adequate. In the other five subjects, bled 900 to 1050 cc. systolic and diastolic pressures fell markedly, in these the critical point had been exceeded and the compensatory mechanisms were inadequate. These data indicate that the existence of "normal" systolic and diastolic blood pressures do not rule out the occurrence of a small to moderate hemorrhage particularly in individuals with excellent compensatory mechanisms.

The presence of moderate to intense vasoconstriction is probably better evidence of occult hemorrhage, since this indicates that the sympathetic nervous system has been called into activity. Foster and

associates⁵ measured volume changes in the fingers and toes of patients undergoing shock producing operative procedures. These plethysmograms showed that marked vasoconstriction occurred five to thirty minutes before blood pressure began to fall. Conversely in fusion of plasma or whole blood in patients with shock and marked hypotension caused a return of blood pressure to normal values before the constricted vessels relaxed to any considerable extent. Plethysmograms approached normal only after further amounts of blood plasma or substitutes had been administered. If blood pressure criteria had been used therapy would have been discontinued while the patient was still in a precarious state the circulation being maintained only by the maximal functioning of compensatory mechanisms.

Furthermore "normal" pulse rate does not rule out a diagnosis of hemorrhage for pulse acceleration does not always occur following hemorrhage in unanesthetized man. Shenkins group⁴ bled normal volunteers 500 to 1500 cc and found that many subjects while supine had no significant change in pulse rate. They divided the effects of hemorrhage on healthy men into three stages of severity. "In the first stage the subject is symptom free at rest and has a pulse rate and blood pressure within normal limits. However on arising an undue acceleration of pulse rate and some diminution of blood pressure are found. In the second stage there are still no noteworthy abnormalities as long as the subject is recumbent and at rest. But the upright position cannot be tolerated and syncope soon overwhelms the subject if he arises. In the third stage syncopal attacks accompanied by bradycardia occur even though the subject is at rest and recumbent." In other words a diagnosis of hemorrhage cannot be made in otherwise normal men by the pulse rate or by the level of arterial blood pressure if the patient is supine. However occult hemorrhage may be detected by having the patient stand or tilting the patient into the feet down position at this time either marked tachycardia or marked bradycardia may occur and either may be followed by abrupt syncope. A diagnosis of internal hemorrhage may be overlooked if the patient is examined only in the supine position.

Pulse slowing not only follows hemorrhage but usually accompanies the low blood pressure that occurs in fainting⁶ or in the vasomotor collapse that is frequently seen in unanesthetized individuals tilted into the feet down position.⁷ Cerebral anemia occurs in all of these instances. Since bradycardia usually is noted also in the cerebral anemia attendant upon an increase in intracranial pressure it appears that anemia of the brain from any cause leads to bradycardia in unanesthetized persons. One would expect that in severe hypotension the pulse should be maximally accelerated because of the release of the normal inhibitory influences to the vasomotor center from the pressure receptors. Some new factors capable of blocking carotid sinus and aortic arch pressure receptor reflexes must operate

in these instances Bradycardia rarely accompanies severe hypotension in dogs or men anesthetized with ether or barbiturates. It is likely, therefore, that the bradycardia arises from the cortical regions which are most easily depressed by narcotics. Further evidence along these lines is provided by the occurrence of bradycardia during spinal anesthesia, under these circumstances the cardiac sympathetics may be blocked peripherally by a high level of anesthesia (T_1 - T_5). Bradycardia does not as a rule accompany the hypotension of traumatic shock (as in simple hemorrhage) probably because of the intervention of simultaneous pain impulses, which tend reflexly to accelerate the pulse.

2 **The Effect of Position upon the Circulation.**—When normal man changes from the supine position into an ambulatory state, symptoms suggestive of circulatory collapse rarely occur. Yet it has been shown that assumption of the erect position immediately pools at least 500 cc of blood in the lower extremities simply by the force of gravity. The veins, venules and capillaries are distended by blood. The surgeon is familiar with the phenomenon of a patient "bleeding into his own capillaries" because of the widespread capillary dilatation that may accompany traumatic shock. Placing the patient in the sitting or vertical feet-down position may be entirely analogous to the capillary pooling in shock, both may reduce effective blood volume and venous return. This phenomenon was noted more than a century ago. The following quotation is from Leonard Hill's classical article upon the effects of gravity: "Piorry in 1826 was summoned to a patient who had been trampled upon in the belly by a horse. He was found supported by his friends in the sitting position and almost died. Piorry immediately placed him horizontally and the patient at once recovered. After Piorry's departure, the patient insisted on taking his seat again in the carriage. On doing so, he immediately became unconscious and died."

Normal man does not faint upon getting up because compensatory mechanisms immediately come into play to stabilize blood pressure. True, systolic blood pressure falls slightly as a result of the decreased venous return to the heart. However, pulse rate and diastolic blood pressure rise as a result of increased sympathetic activity to the heart and vessels, these changes are reflex ones initiated by the fall in the aortic arch and carotid sinus pressure that occurs upon standing. Furthermore, if the subject is ambulatory, the contractions of his leg and thigh muscles force more blood upward and so increase venous return. In a normal individual, these compensatory actions suffice to maintain blood pressure and an adequate circulating blood volume.

Certain abnormal procedures or conditions tend to deprive the individual of his compensatory mechanisms or to accentuate the effect of change of position. These may be listed as follows:

(a) When an individual is made to assume an erect position with-

out muscular movements of the legs, the force which normally supports the leg veins and pumps blood back to the right side of the heart is decreased. Such a condition is easily obtained by tilting an individual lying on a board into the feet-down position. If the subject is kept motionless in this position long enough, he will usually develop circulatory collapse and faint. The average individual does not faint if maintained in this position for ten to fifteen minutes, and such a test is sometimes used as an indication of the adequacy of an individual's circulatory compensation.

This muscular pumping or supporting action may be depressed or abolished in spinal anesthesia, deep general anesthesia and during curarization. It is more dangerous to operate upon individuals so deprived of this protective mechanism, especially if the operation involves considerable blood loss. Patients with muscle atrophy as a result of disease or prolonged bed rest are more apt to faint when tilted feet down.

(b) Extensive sympathectomy deprives the patient of many of his compensatory mechanisms and so increases the risk of fainting when the patient is shifted to the upright position. Pharmacological sympathectomy may soon be a reality since the discovery⁸ that dibenzyl-B chloroethyl amines may block for long periods all sympathetic motor activity in man. Caution should be used in the employment of such drugs since their use decreases the normal protection of the body against hemorrhage and postural change.

(c) Any drug or procedure which in itself produces marked peripheral vasodilation decreases the effectiveness of compensatory mechanisms since the vasodilation opposes the attempts of the sympathetic system to constrict vessels. Thus nitrites, by widespread peripheral vasodilation, pool blood in the extremities and so favor postural hypotension. Likewise morphine dilates peripheral vessels and tends to favor the development of hypotension. Drew and his associates⁷ have shown that fainting was four times as apt to occur when morphinized individuals were tilted feet down as when normal individuals were tilted. It is probable that large doses of morphine predispose toward shock, especially when the " " " " by hemorrhage or by prolonged " " " " has been presented which suggests:

It should be emphasized that a warm humid environment may also aggravate the effects of hemorrhage and postural change. The use of external heat has long been employed as a means of increasing blood flow locally by inducing vasodilation. However, when heat is applied to the whole body or when body temperature is elevated as in fever due to disease or to physical therapy, widespread vasodilation may occur. Under these conditions, hypotension is more apt to follow hemorrhage or tilting feet down. It is possible that some of the hypotension seen during surgical operations results from the use of hot,

humid operating rooms. A cooler environment may prevent this by maintaining better vascular tone.

(d) The compensatory mechanisms are decreased when the vasomotor centers are depressed by trauma, deep anesthesia, or prolonged anoxia.

(e) The effect of postural change is accentuated by decreased circulating blood volume, as in hemorrhage or shock. In these conditions the venous return is already deficient and further reduction, due to gravitational factors, may overwhelm the compensatory mechanisms.

Circulatory depression in the upright position may be prevented wholly or partially in a number of ways. Pooling of blood in the extremities can be prevented by the use of elastic bandages from the toes to the groin or possibly by the use of pressure suits developed during the war to combat the effects of accelerational gravity. Another preventive measure is the administration of sympathomimetic drugs which increase the tone of arterioles or venules and so prevent blood accumulations there. MacLean believes that "training"—by maintaining an individual in the feet-down position in bed for increasing intervals each day—prevents or reduces postural hypotension.⁶ Early ambulation (postoperatively) may prevent postural hypotension by not permitting the skeletal muscle atrophy that occurs following prolonged bed rest.

SUMMARY

1. The physiological mechanisms which tend to prevent circulatory collapse in hemorrhage or, in the enforced feet-down position have been discussed.
2. A diagnosis of extensive hemorrhage (1000 to 1200 cc. of blood) cannot always be made by observation of the pulse and blood pressure. Occult hemorrhage can often be detected by measurements of peripheral compensatory vasoconstriction or by observations of pulse and blood pressure when the individual is tilted feet-down.
3. The measures which accentuate or reduce the effects of blood loss and of prolonged tilting have been discussed.

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CIRCULATORY CHANGES DURING SPINAL ANESTHESIA: THEIR PHYSIOLOGICAL BASIS

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* SPINAL anesthesia can cause a decrease in blood pressure. From the *clinical* standpoint a number of factors have been found to influence the incidence and degree of this hypotension. For example, if a pressor drug was not administered prior to the onset of anesthesia an average fall in systolic blood pressure of 36 per cent from the preoperative level was noted in an unselected series of 500 patients.¹ If methedrine (20 mg.) was given intramuscularly at the time of the lumbar puncture the average decrease in systolic pressure was reduced to 3 per cent in a comparable series. One can expect a greater incidence of circulatory depression with higher levels of spinal anesthesia, in older patients, and in individuals whose initial blood pressures are above normal. These facts have been established statistically.¹ Clinicians vary in their opinions as to the effect on blood pressure of the different drugs used for the production of spinal anesthesia. In our experience there has been no difference between procaine and pontocaine as far as vascular response is concerned. Data on other agents such as nupercaine, metycaine, monocaine and intracaine are not yet available. Clinical impressions are therefore being subjected to statistical analysis and the facts outlined above have been established.

The most satisfactory approach to the circulatory adjustments made during spinal anesthesia is to measure these by *physiological* yardsticks. Data on cardiac output, venous pressure, renal blood flow and other factors influencing blood pressure have accumulated and theories as to the etiology of the decrease in arterial tension have evolved. In this presentation the experimental evidence will be reviewed and an attempt made to incorporate this material into a working hypothesis with practical applications as far as prophylaxis and treatment is concerned.

A great deal of the data on the relation of spinal anesthesia to the circulation is based on animal experimentation. This body of evidence will not be considered here since its applicability to man is questionable in many instances. For example, the cat, dog and rabbit on whom most observations have been made are four-legged creatures, differing from man in the postural circulatory adjustments demanded. Their

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carotid sinus aortic arch compensatory mechanisms are less sensitive and the tendency to "buffer out" a decrease in blood pressure is less. These animals also are at a distinct physiological disadvantage when placed on their backs the position utilized in most laboratory investigations. Burstern² has pointed out that dogs under total spinal anesthesia with blood pressures of 50 mm. of mercury in the supine position showed a sustained rise in arterial pressure to 120 to 150 mm. of mercury when turned on the left side. Smith and colleagues³ note the possibility that tying a cat or dog down on its back with legs extended may seriously embarrass the venous circulation. The introduction of an anesthetic and the failure to properly train animals for observations in the unanesthetized state are other reasons for omitting animal data since the state of the vascular system under these conditions cannot be regarded as normal. We shall therefore consider only circulatory measurements made in man.

Spinal anesthesia that is the introduction of a local anesthetic into the subarachnoid space results in a block to conduction in various nerve pathways. Clinically the onset of spinal anesthesia is characterized by a rise in skin temperature in the affected area. This is followed by loss of sensitivity to heat and cold then to cutaneous and pressure pains. The order of loss of these sensations is distinct though only a brief time interval elapses between their disappearance. Following a distinctly longer period loss of motor function occurs then after another short interval loss of joint sense and touch.⁴ This differential susceptibility appears to depend primarily on fiber size.⁵ Small unmyelinated or lightly myelinated fibers such as those which carry sympathetic constrictor impulses to blood vessels are blocked before the larger more heavily myelinated sensory and motor fibers. If the concentration of the local anesthetic is sufficiently low motor paralysis will not occur. Thus one can avoid motor block entirely by administering dilute solution or one can block motor activity in the lower areas of the cord only since as the anesthetic agent rises in the subarachnoid space it becomes diluted by spinal fluid and the resulting concentration is insufficient to affect motor nerves. The phenomenon of a very high sensory level (clavicles or above) without dangerous depression of respiratory exchange (intercostal muscles relatively spared) is thus partially explained. Another reason for this divergence between motor and sensory levels is that the anterior or motor roots are probably exposed to a lower concentration of anesthetic agent when the patient is supine and a solution is used which is heavier than spinal fluid.

The significance of this difference in reactivity is as follows: in one patient spinal anesthesia may provide pain relief without the production of any degree of muscular paralysis; in another the sensory level may be almost complete yet the upper intercostal muscles and diaphragm are spared and tidal air is unchanged; in a third patient

sensory and motor block may both be almost complete. As will be seen the circulatory reactions under such circumstances may be quite different.

ARTERIOLAR DILATATION

The first thing noticed by the average patient after the introduction of a spinal anesthetic is a feeling of warmth in the legs. In a normal individual the rise in skin temperature in the lower extremities may be as great as 10°C . This is presumptive evidence of cutaneous vasodilatation. On the basis of this reaction the original theory of the cause of hypotension associated with spinal anesthesia was that of arteriolar dilatation and a decreased peripheral resistance. This assumption was strengthened by the observations that vasomotor nerves were the first fibers affected by local anesthetics.*

The relationship between the interruption of conduction in vasomotor nerves supplying arterioles and the arterial hypotension seen after spinal anesthesia depends upon whether there is or is not a tonic discharge of constrictor impulses from the vasomotor centers in the medulla and spinal cord to the vessels of normal, unanesthetized man. If tonic activity exists, block of such impulses would result in arteriolar dilatation, reduction of peripheral resistance and a decrease in diastolic level of pressure. Furthermore, if this were the only vascular change arteriolar dilatation should be associated with an increased venous pressure and an increased cardiac output, at least until circulatory collapse was imminent.

Using digital plethysmographs, Neuman and his co-workers^{6,7} measured the effects of spinal anesthesia on the peripheral circulation in the index finger and second toe of twenty-eight patients. In twenty patients (upper limit of sensory anesthesia between T_{11} and T_4) the blood pressure remained essentially unchanged. Within two to five minutes after the injection of the anesthetic, pulse waves in the toes increased three fold and there was a marked increase in the volume of the toe tip. Concurrently, the plethysmogram of the finger showed a decrease in volume of the pulse waves and a gradual decrease in the total volume of the finger. In the eight other patients there was a fall of the systolic blood pressure level of 40 to 80 mm of mercury accompanied by a fall of about half of this amount in the diastolic pressure. In four of these patients the response of the toes was the same as in those individuals whose blood pressure remained unchanged. In the fingers, however, there was an increase in volume of pulse waves. In the remaining four patients both finger and toe showed a marked decrease in size of the pulse waves.

Since fingers and toes, disregarding the bone and tendons, are composed almost entirely of skin, blood flow readings for the most part represent cutaneous circulation.^{8,9} The findings just noted therefore indicate that vessels in the skin are in a state of partial constriction, presumably as the result of tonic activity of the vasomotor center.

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blood flow changes in the forearm and leg represent changes in vascular beds of muscle more than in those of the skin. The data of Prinzmetal and Wilson¹⁰ suggest the presence of tonic constrictor activity in muscle. These workers blocked the upper dorsal sympathetic ganglia of normal individuals with procaine and measured blood flow by a forearm plethysmograph. Anesthetization of the vasomotor nerves to the arm produced a 75 per cent increase in forearm blood flow. Similar results were obtained by Barcroft and associates who found in addition that this response did not occur in sympathectomized subjects.¹¹ There can be little doubt of the presence of tonic vasomotor activity in blood vessels supplying muscles. It is estimated that release of such tonus throughout the body musculature would increase its blood flow by 1.5 liters per minute.¹²

A decreased arteriolar tone as has been pointed out should result in a diminution in diastolic pressure. Blood pressure readings after spinal anesthesia indicate a decrease in both systolic and diastolic levels of pressure. Although the decrease in the former figures is greater as far as the number of millimeters of mercury is concerned,³ the percentage decrease is similar for both values.¹ This is further evidence of tonic constrictor activity in normal man.¹

Rovenstine, Papper and Bradley¹³ have calculated peripheral resistance in seven patients under spinal anesthesia with sensory levels ranging from D₂ to C₆; three patients showed a decreased peripheral resistance (12 to 27 per cent), two showed no change and two showed an increase (6 to 22 per cent). Failure to observe more of a diminution in resistance under these conditions has caused these workers to postulate maintenance of arteriolar tone during spinal anesthesia. This viewpoint is supported by data of Smith and co-workers² on renal blood flow during spinal anesthesia. These authors on the basis of phenol red and diodrast clearances state that "spinal anesthesia has negligible effects upon the renal circulation. We conclude that the normal tone of the renal vessels is not significantly dependent upon sympathetic nervous impulses of central origin." This latter work has been of real service to physiologists since it focuses attention on the possibility of local or humoral control of blood vessel tone in addition to control mediated through vasoconstrictor impulses from the central nervous system.

(In summary it seems evident that there is vasomotor tone in human cutaneous and muscle arterioles and that this activity can be abolished by block of sympathetic nerves as would occur in spinal anesthesia. The tonus of arterioles in the viscera has been measured only in the kidney so that it is not yet possible to determine the part played in maintenance of blood pressure by resistance in vessels in the splanchnic

nic area, heart and brain. One of the factors in the decrease in blood pressure after spinal anesthesia is diminished arteriolar tone and decreased peripheral resistance. That this is by no means the only physiological alteration responsible for the hypotension will be evident later.

VENOUS PRESSURE

If diminished arteriolar tone were the only factor concerned, venous pressure should rise initially as the increased flow in the capillaries is transmitted to the venous side of the circulation. Adriani and Rovenstine¹³ measuring antecubital vein pressure directly observed a decrease in venous pressure irrespective of a change in arterial pressure with levels of spinal anesthesia which decreased intercostal muscle activity (T_4 or above). A further decrease in venous pressure occurred if arterial hypotension developed. No consistent changes were noted in "low spinals." These authors apparently did not observe any instance of an initial increase in venous pressure. Data of a similar nature were reported by Doud and Rovenstine¹⁴ who studied circulation time from the antecubital vein to the mouth, perineum, face, hands and feet. With levels of spinal anesthesia to T_6 or above there was a constant decrease in the velocity of blood flow as determined by this method.

VENOUS TONE

The decreased venous pressure and slowed circulation noted above are probably caused by stagnation or pooling of blood in capillaries, venules and veins. This latter could be due to loss of skeletal muscle tone in the lower extremities and abdomen,¹⁵ or to the abolition of tonic constrictor impulses to veins. That veins can constrict can readily be demonstrated by direct stimulation of these structures. A renal vein, for example, can be seen to narrow to the point of almost complete obstruction following direct trauma. Evidence of the presence of tonic constrictor impulses from the vasomotor center in the maintenance of venous tone has not been obtained in normal man, but certain observations in this direction are pertinent. Papper and Imler¹⁶ believe that the deep veins of the lower extremity are innervated by the lumbar sympathetic outflow. These authors state that excessive tone of this outflow can exist, resulting in spasm of the deep veins. Denervation of the veins by lumbar sympathetic block effectively removes this excess venous tone and allows the veins to dilate. These opinions were substantiated by phlebographie evidence. Sousa-Pereira¹⁷ has also demonstrated increased venous circulation following interruption of the lumbar sympathetic chain. Venospasm of a degree sufficient to hinder or prevent blood transfusions has been reported under conditions of severe shock or hemorrhage.¹⁸ During shock or hemorrhage one can assume increased vasomotor activity secondary to removal of inhibi-

tory reflexes from the carotid sinus aortic arch areas. It is logical to postulate that in addition to maximal narrowing of arterioles, the body would attempt to compensate for hypotension by decreasing the vascular capacity of veins. Apparently this can attain such proportions that the introduction of fluid into veins can be accomplished only under pressure. On the basis of this type of data it seems reasonable to conclude that there are tonic constrictor impulses to veins and that spinal anesthesia can reduce venous pressure through venous dilatation.

CARDIAC OUTPUT

The venous stagnation described above should be reflected in a diminished venous return to the heart and a decreased cardiac output. Determinations of cardiac output in man before and after spinal anesthesia are not common. Schubert¹⁹ using Grollman's method reported a decrease in cardiac output in 10 per cent of fourteen patients with sensory levels between T₅ and T₇. In four other patients cardiac output increased. His studies were made just prior to operation, after ephedrine had been administered, and his control readings are questionable because of the anxiety of his subjects. Rovenstine and associates²⁰ studied seven patients with the ballistocardiograph. Three individuals showed no change with sensory levels of D₄. Four others showed a decrease in cardiac output per minute, ranging from 11 to 22 per cent of control figures. The height of spinal anesthesia in these instances was D₅ to C₆. In three of the four patients the heart rate remained relatively constant so that a diminution in stroke volume was evident. Correlation between cardiac output and mean arterial pressure was rather close in four of the seven patients, but in two others mean pressure fell considerably more than cardiac output, and in a third patient, despite a 16 per cent decrease in cardiac output, mean pressure rose 3 per cent. It is evident that a diminution in cardiac output per minute frequently occurs, but that this is not the only cause of a decreased arterial pressure during spinal anesthesia.

Important observations on the relationship between cardiac output and arterial hypotension have recently been made by Barcroft and associates²¹. These investigators measured cardiac output by the direct Fick principle with right heart catheterization. Volunteers were bled by venesection, or blood volume was reduced by venous tourniquets. A typical experiment was as follows. During venesection heart rate increased while cardiac output and right auricular pressure fell. Blood pressure was largely maintained in spite of the decrease in cardiac output and therefore constriction must have occurred in the peripheral vascular system. A few minutes after the end of venesection blood pressure fell suddenly, the pulse slowed and consciousness was lost. During the fainting spell cardiac output and right auricular pressure were higher than at the end of venesection when blood pressure was still maintained. It was clear that there had been a sudden great de-

crease in total peripheral resistance. This was evident in increase in forearm blood flow measured plethysmographically.

In other words, decreased arterial blood pressure may be related to diminished cardiac output or diminished peripheral resistance, or both. During spinal anesthesia as in posthemorrhagic fainting discussed above, these variations are encountered.

Associated with or as the cause of acute circulatory collapse there is often a sudden slowing of the pulse rate. This has been noted in posthemorrhagic fainting²⁰ in the loss of consciousness accompanying assumption of the upright position²¹ and in spinal anesthesia²². Heart rate may decrease to 36 to 40 beats per minute. This reduces cardiac output per minute.²³ Atropine blocks the reaction, so that it can be regarded as due to increased vagal activity. Why vagal centers are stimulated, however, remains uncertain. The important point is that cardiac output drops along with little unless heart rate is known. A sharp reduction in output per minute may be due entirely to bradycardia.

BLOOD VOLUME

There is no information available as to the effect of spinal anesthesia on circulating blood volume in man. From the theoretical standpoint, determinations of blood volume before and after subarachnoid block would be useful. For example, if a patient comes to the operating room with a blood volume distinctly below normal, spinal anesthesia, even confined to the lower sensory levels, may precipitate circulatory collapse. This patient will already be compensating for reduced circulating volume and will be unable to meet the increased demands of spinal anesthesia. A second possibility is loss of fluid from capillaries because of capillary stagnation, anoxia and increased capillary permeability. If this can be demonstrated, even a normal blood volume may be reduced by anesthesia.

RESPIRATORY DEPRESSION

As the level of spinal anesthesia rises in the subarachnoid space an increasing number of intercostal muscles may be paralyzed until in some instances a serious decrease in tidal air occurs. This respiratory depression might affect the circulation in three ways. First because of thoracic muscular paresis or paralysis there is less negative pressure in the pleural cavity during inspiration. The "thoracic pump" action of respiration is thus decreased and less blood is drawn into the chest. Second decreased action of the supra umbilical muscles removes pressure from the abdominal blood vessels and thus decreases the flow of blood towards the heart. Third, depressed tidal exchange may result in inefficient saturation of hemoglobin, a fall in oxygen tension and a rise in carbon dioxide tension, all of which may be detrimental to the vasomotor center.

Again, quantitative studies on the respiratory alterations produced

by spinal anesthesia in man are few Gray and Parsons first called attention to this relationship in 1912 but they offer only very rough data on depth of breathing¹⁵ This was obtained by passing a band around the patient's chest to this was attached a small tambour These workers noted that thoracic excursions became smaller and diaphragmatic excursions became pronounced as the level of anesthesia ascended Schubert¹⁹ measured tidal air in sixty one patients before and after spinal anesthesia Thirteen of the group exhibited a 40 to 70 per cent decrease in systolic pressure after the onset of anesthesia the remainder showed far less change in levels of blood pressure No consistent changes in tidal air were demonstrable for example the degree of change ranged from plus 70 to minus 50 per cent in the individuals with marked hypotension and from plus 66 to minus 51 per cent in the individuals whose blood pressure remained relatively stable In thirty five subjects tidal air increased in twenty six it decreased The data indicate therefore that "considerable falls in blood pressure may exist even though tidal air is increased" There are no data in man on arterial oxygen saturation or carbon dioxide tension at various levels of spinal anesthesia Nor has there been any systematic attempt in man to correct the arterial hypotension during spinal anesthesia with various methods of artificial ventilation Animal work reported by many workers^{4, 5, 6} shows that a normal arterial pressure can be restored with a Drinker respirator or by external pressure on the chest (expiration) followed by manual compression of a breathing bag fitted to a face mask (inspiration) Clinical impressions suggest that inhalation of 100 per cent oxygen is of value in raising a lowered blood pressure and that the deep breaths and straining which accompany vomiting are also helpful in this respect

FACTORS PERTAINING TO SURGICAL INTERVENTION

The physiological alterations discussed above have all been studied in normal unoperated man before and after spinal anesthesia They represent changes in the circulation caused by the introduction of a local anesthetic into the subarachnoid space During surgical operations there are many additional factors which may cause depression of blood pressure These are not peculiar to subarachnoid block but may occur under any type of anesthesia They include traction reflexes excessive use of picks and retractors pressure on the thoracic cage by assistants at the operating table hemorrhage surgical shock and psychic depression secondary to fear In the clinical practice of anesthesia and surgery it may be difficult to distinguish between these various causative agents

AUTHOR'S CONCEPT

It is apparent from the foregoing discussion that many physiological changes combine to produce the decrease in blood pressure associated with spinal anesthesia As the local anesthetic ascends in the sub

arachnoid space, more and more vasomotor pathways to arterioles are blocked. Less certain, but likely, is a similar block of tonic constrictor impulses to veins. In addition to this loss of vascular tone, there occur varying degrees of reduction of the skeletal muscle pressure exerted on veins in the legs and abdomen. Finally, diminished respiratory activity may be mirrored in decreased aspiration of blood into the thorax and a less efficient exchange of oxygen and carbon dioxide in the alveoli.)

The most important single factor will vary from patient to patient. In one individual a decreased peripheral resistance may play the predominant role in precipitating vascular collapse; in another respiratory depression with anoxia may be the final factor responsible for a break in circulatory compensation, in a third the principle cause of the hypotension may be a blood volume which was low prior to onset of spinal anesthesia and proves inadequate to fill the increased vascular bed.

Any tendency towards a lowered pressure in the carotid sinus-aortic arch area immediately decreases the stream of inhibitory impulses which these stretch receptors have been sending to the vasomotor center. Increased vasoconstriction can therefore be expected in peripheral areas whose nerve supply has not been interrupted by the anesthetic agent. In some individuals with reactive vessels this compensatory constriction can maintain circulatory adequacy. In others, compensation fails to develop, perhaps because of arteriosclerosis, perhaps because of abnormal nerve supply. If the circulating blood volume is borderline prior to spinal anesthesia, even a small increase in vascular volume will be poorly tolerated.

In the day-by-day use of spinal anesthesia, patients will be encountered who show no depression of blood pressure despite a sensory level above the clavicles. These are usually young individuals in whom compensatory constriction is maximal, whose blood volume is adequate and who may possess a greater tendency towards the development of autonomous tone in peripheral vessels. Other patients will have *alarming hypotensive reactions with sensory levels below the umbilicus*. These individuals are usually in the older age groups, presumably with arteriolar sclerosis and less ability to compensate. As has been pointed out, quantitative measurements of various circulatory components indicate at one time one significant change, at another time another. The multiplicity of elements concerned with circulatory adequacy make this understandable. There is a need for further study of the problem in man, for the paucity of data in the human is impressive.

PRACTICAL ASPECTS

The circulatory alterations caused by spinal anesthesia make this method particularly indicated for patients with mitral stenosis requiring operation, if the operative site is within the reasonable limits

ing operation, if the operative site is within the reasonable limits reached by subarachnoid block. The pathological physiology of mitral stenosis is that of incipient pulmonary congestion, increased venous pressure and increased work by the right side of the heart. Spinal anesthesia by pooling blood in the periphery, by dilating veins and decreasing venous pressure can be regarded as a bloodless phlebotomy, a procedure indicated for this particular type of cardiac abnormality. By the same reasoning, spinal anesthesia may be employed in the therapy of pulmonary edema.²⁷ With such a method of treatment, diminution of venous pressure can be accomplished without a reduction of hemoglobin. This may be of importance in patients with low hemoglobin levels. Only a few case reports are available and the technic must be regarded as experimental.

Prophylaxis and therapy of postspinal hypotension involves the use of pressor drugs. When the various sympathomimetic amines such as ephedrine, neosynephrine and methedrine were originally employed the thought was that these substances exerted their effects by a peripheral arteriolar constriction. It is now recognized that their action is more widespread, involving in addition a constrictor action on veins and a direct stimulant effect on the myocardium. It is interesting to note that these actions are all indicated during spinal anesthesia.

The multiplicity of circulatory actions following spinal anesthesia makes it evident that this method can be a poor diagnostic tool in the detection of hypertonicity of the sympathetic nervous system in such disease entities as peripheral vascular disease, causalgia and hypertension. So many factors enter into the changes in blood flow and blood pressure after spinal anesthesia that a prediction of the effects of surgical sympathectomy is difficult.

If venous stagnation and pooling of blood in the periphery is an important cause of a low blood pressure, bandaging the lower extremities,⁸⁻¹² stimulation of skeletal muscle electrically¹³ or assumption of the Trendelenburg position¹² should all be useful therapeutic adjuncts. Although these measures occasionally are of value, in many instances they have proved disappointing. This is one more indication of the complexity of the problem. Use of pressure or blackout suits developed for aviators might be of more help since, in addition to support of leg blood vessels, there is increased pressure on abdominal vessels as well. Such suits, of course, could not be used in surgical practice.

SUMMARY

The physiological basis underlying the decrease in blood pressure associated with spinal anesthesia has been discussed. A variety of alterations in function combine to produce this hypotension. The predominance of each factor varies from patient to patient. Some of the practical applications of these functional changes in the circulation have been presented.

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VENOUS THROMBOSIS AND PULMONARY EMBOLISM

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With a reduction in the morbidity and mortality in surgery as the result of improved pre and postoperative care, the use of new chemotherapeutic agents, and effective measures for preventing and combating peripheral vascular collapse, increasing interest has been shown in the less common problems which complicate surgical procedures. Among these problems are venous thrombosis and pulmonary embolism. Numerous studies during the past few years have increased our knowledge of the pathologic physiology of thrombosis and embolism and have introduced new concepts which are proving helpful in the search for successful methods of prevention and treatment. Important recent concepts which are rapidly gaining acceptance are the following:

1. Venous thromboses of clinical importance, including those which cause pulmonary embolism, usually originate in the veins of the lower extremities, principally in veins below the knee.

2. Venous thrombosis and pulmonary embolism occur as commonly in the "medical" diseases as they do following surgical operations.

3. Venous thrombosis in the lower extremities of middle aged and elderly persons confined to bed is a frequent occurrence, being found in about 50 per cent of such persons dying from all causes.

4. Acute thrombophlebitis and phlebothrombosis, or blood thrombus formation, are distinctly different pathological and clinical entities. In acute thrombophlebitis, which is readily recognized clinically by a marked inflammatory reaction and vasospasm, thrombi are usually firmly adherent to the walls of the involved veins. In phlebothrombosis, which often has minimal clinical symptoms and signs, or may not be recognized clinically, the thrombus is so loosely attached to the vein wall that it may be easily dislodged, with resulting pulmonary embolism.

In recent years new prophylactic and therapeutic techniques, notably the use of anticoagulants and of proximal vein ligation, have been introduced. Even though they have not proved to be the final answer to the problem, recent progress has done much to allay discouragement regarding thrombosis and embolism. The former (and relatively recent) belief that deaths due to pulmonary embolism are "unavoidable catastrophes," has been largely replaced by a confidence that

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these deaths can be minimized or possibly eliminated by further improvements in prophylactic and therapeutic measures

INCIDENCE

The frequency of venous thrombosis in the postoperative period cannot be stated with certainty. Reported incidences in clinical studies range from a fraction of 1 per cent to more than 10 per cent probably because of the variability of diagnostic criteria. Although the diagnosis of classical acute thrombophlebitis may readily be made signs and symptoms may be minimal or absent in phlebothrombosis. Thus the frequency of silent thrombosis cannot be accurately determined by clinical methods. Laboratory tests designed to show an increased tendency for the blood to clot do not at present detect the presence of intravenous clotting to the exclusion of other factors which may increase the coagulability of the blood. Recent demonstrations^{1, 2} that venous thromboses occur commonly in middle aged and elderly persons dying from any cause suggest that postoperative intravenous clotting may be much more frequent than previously reported or suspected.

Since the incidence of postoperative thrombosis is uncertain the frequency with which pulmonary embolism follows thrombosis is also unknown. The occurrence of pulmonary embolism following diagnosable phlebitis may be ascertained but the comparability of different studies is of questionable value because of different criteria used. Welch and Faxon³ using rigid diagnostic criteria found in 250 cases of recognizable phlebitis that one in three had an infarct, while one in twenty five developed fatal pulmonary embolism.

Information concerning the occurrence of fatal pulmonary embolism following surgical operations is somewhat more definite. Allen⁴ states that the incidence of fatal embolism in the convalescent period is 1 in 800. At the Henry Ford Hospital in Detroit in an analysis of 118,611 operations Lam and Hooker⁵ found that fatal embolism was responsible for the death of one patient in each 1500 operated upon for all reasons. In a statistical analysis of more than 178,000 operations at the Mayo Clinic⁶ fatal embolism was found to occur in about 1 in 800. At the Hospital of the University of Pennsylvania in a study of more than 66,000 operations we have found the incidence of fatal embolism to be about 1 in 1200 operations.

Pulmonary embolism is the cause of about 5 per cent of all postoperative deaths.

PREDISPOSING FACTORS

Normally blood does not clot within the veins during life. The powerful hemostatic mechanism of blood coagulation is instantly available however to arrest the loss of blood when injury occurs. Without this mechanism or if this mechanism were less effective even trivial in-

juries would be extremely serious and all surgery would be hazardous. For these reasons the predominance of medical and surgical interest in the past has been in aiding blood coagulation. The current use of thrombin, fibrinogen and other agents which aid in coagulating blood are representative of the fact that in certain conditions the normal blood clotting mechanism does not stop blood loss adequately, even with the help of the usual surgical, hemostatic maneuvers. Under certain circumstances discussed below, on the other hand, clotting of the blood in the veins during life does occur. A thorough knowledge of the conditions under which this occurs is of obvious importance if intravenous clotting is to be prevented.

The classical triad of factors thought to be involved in venous thrombosis is (1) slowing of the circulation, (2) increased coagulability of the blood and (3) injury to the intima of the veins. In patients who develop thromboembolic disease one or more of these factors can usually be shown, or presumed, to be present, although little is known about the relative importance of the three factors or whether any one factor alone is sufficient to cause intravenous clotting under predictable circumstances.

Slowing of the circulation in the lower extremities may occur as the result of any interference with the factors concerned in venous return, i.e., negative pressure within the thorax, the pumping action of skeletal muscles, and capillary pressure. Following many operations, particularly laparotomy, hypoventilation is common, with diminished effectiveness of the thoracic pump. The importance of this mechanism has been demonstrated experimentally.⁷⁻⁹ The frequency of thromboembolic disease following operations on the abdominal viscera has led many to suggest that postoperative abdominal distention after such procedures may slow the venous return from the legs. The experiments of McLaughlin and Levering⁸ with acute gastric dilatation support this view.

The effect of immobilization in slowing the circulation of the lower extremities has long been recognized, and this factor is commonly thought to account for the frequency of thromboembolic disease in patients immobilized for long periods, e.g., certain fractures. Potts and Smith⁷ have shown in experiments on dogs the effectiveness of exercise in increasing the venous return from the legs.

In clinical studies the incidence of thromboembolism has been found to be higher in patients with cardiovascular disease,¹⁰⁻¹¹ presumably because of decreased circulation time. McCartney¹² found thromboembolism to occur three times as commonly in persons with heart disease as in persons with normal hearts. Smoking, believed to cause an increased tendency to thrombosis by its vasospastic effect, has been emphasized as a contributing factor of some importance.¹⁵

The vasospastic effect of cold is thought to account for the difference in incidence of intravenous clotting in warm and cold weather.

and in different parts of the country^{14 15} In general, intravenous clotting has been found to occur more commonly in winter and spring than during summer months, and the incidence is higher in northern states than in the South Ochsner¹⁵ states that the average incidence in northern states is 0.74 per 100,000 population as compared with 0.41 per 100,000 population in southern states

Other factors which may influence the incidence of thromboembolism by affecting the circulation are obesity¹⁶ and varicose veins⁶ Finally, the circulatory retardation accompanying old age, even in the absence of conspicuous cardiovascular disease, may contribute significantly to the predominance of intravenous clotting in the old age group

The similarity of the process of venous thrombosis to the normal mechanism of blood coagulation has led many to believe that the effect of various factors in increasing the coagulability of the blood may be of major importance in precipitating thrombus formation Ochsner¹⁷ states that injury to tissue from operations, accidental trauma, deliveries, and infection or malignant disease, results in increased coagulability of the blood because of the "absorption into the blood stream of noxious substances derived from the traumatized cells" Increased coagulability is thought to result from changes in the plasma and in the formed elements of the blood Changes in the plasma consist of increased viscosity, hypoproteinemia, hyperglobulinemia, increased fibrinogen content, increased antitryptic power, increased peptidase increased calcium content, and decreased carbon dioxide combining power The altered albumin-globulin ratio causes an increased erythrocytic sedimentation rate Changes in the cellular elements consist of an increase in thrombocytes and leukocytes, a decrease in erythrocytes, and increased agglutinability of the thrombocytes, which is "probably responsible for the initiation of a thrombus" De Takats believes that "any lesion which liberates thrombokinasase will accelerate blood clotting," citing as examples injuries to tissues, especially muscles, massive wounds of the extremities and surgical trauma

Since the usual simple tests of the clotting mechanism do not reveal increased clotting tendencies with any reliability, more sensitive tests for detecting increased coagulability have been sought For this purpose de Takats¹⁸ has proposed the "heparin tolerance test" This test is based on the response to the intravenous administration of 1 cc (10 mg) of heparin as determined by the clotting time (capillary tube method) ten, twenty, and thirty minutes after the injection A decreased response to heparin, indicating an increased clotting tendency, has been found in postoperative patients, in Buerger's disease, and in the presence of any kind of intravascular clotting The normal response to heparin can be restored by the administration of heparin or dicumarol An increased clotting tendency may also be detected by the prothrombin time determination, using diluted plasma¹⁹ This test

can be performed with accuracy only by highly trained technicians. Evaluation of the usefulness of these tests in determining whether a patient is likely to develop, or has already developed, a thrombus, will obviously require careful study of large numbers of patients.

The effectiveness of injury to vessels in causing thrombosis has been shown repeatedly in animal experiments. The influence of this factor clinically is doubtless of importance in traumatic lesions of the lower extremities, particularly in fractures. The importance of injury to vessels per se is difficult to evaluate in many instances, however, because of the presence of another factor, i e., slowing of the circulation due to immobilization. Intimal changes in diseases characterized by frequent thrombosis, such as Buerger's disease and arteriosclerosis, may contribute largely to thrombus formation.

Although thromboembolism may occur after operations on any part of the body, it occurs more frequently after operations on certain parts of the body and on certain viscera. In addition, the magnitude of the operation is of obvious importance, since these complications are rare after operations which affect but slightly the patient's normal

TABLE 1—SEX DISTRIBUTION OF PULMONARY EMBOLISM
IN 67,400 OPERATIONS

	All Cases of Embolism	Fatal Cases
Males	76	35
Females	42	19
Total	118	54

activities. Thrombosis and embolism occur most commonly after operations on the bladder and prostate, the stomach, uterus, colon and rectum, biliary tract, appendix, and inguinal hernia, and after severe fractures of the lower extremities. The incidence is considerably lower after operations on the head, neck and throat. At the Hospital of the University of Pennsylvania there has not been a single instance of embolism, fatal or nonfatal, after thyroidectomy. This has also been the experience at the Henry Ford Hospital in Detroit.⁵ Since postoperative thromboembolism follows operations on abdominal viscera in a high percentage of instances, it seems fair to assume that opening the abdominal cavity must be a factor of considerable importance in the development of these sequelae. Thus, as mentioned previously, may be due in part to the abdominal distention which frequently follows these operations.

In evaluating the etiologic influence of the part of the body operated upon, two other factors must be considered, i e., age and sex. Operations on the prostate and bladder, for example, are done principally in the fifth, sixth and seventh decades, the time of life when thromboembolism is most prone to occur. In regard to sex differences,

pulmonary embolism, both nonfatal and fatal, occurs more commonly in men than in women in a ratio of about 3 : 2, as will be seen in Table 1. This is in close agreement with the findings of others.^{5, 6}

The importance of age as a predisposing factor in pulmonary embolism has long been recognized. In most statistical studies it has been shown that the majority of patients are above the age of forty when embolism occurs. This has been striking in our experience, as is shown in Table 2. Of all persons who had embolism, 84 per cent were above the age of 40, and of those who had fatal embolism, 92 per cent were

TABLE 2 —AGE DISTRIBUTION BY DECADES OF PULMONARY EMBOLISM IN 67,400 OPERATIONS

Decade	All Cases of Embolism	Fatal Cases
0-9	0	0
10-19	2	0
20-29	5	3
30-39	11	1
40-49	19	5
50-59	37	16
60-69	26	16
70-79	16	13
80-89	0	0
Total	118	54

above the age of 40. Only four of fifty-four patients who had fatal embolism were below the age of 40.

The number and variety of predisposing factors emphasize the complexity of the problem of thromboembolism. Each of these factors is doubtless of importance in certain instances. The coexistence of a number of these factors in one individual probably increases the likelihood that a thromboembolic complication may develop. Of all the factors considered, however, there are two which stand out above the others in importance, since they coexist in more than 80 per cent of all embolisms, fatal and nonfatal. These are (1) the patient is above the age of 40, and (2) the patient has been confined to bed for a few days or longer.

PROPHYLAXIS AND TREATMENT

In recent years it has become widely recognized that the most logical approach to the problem of thromboembolism is prophylaxis. Excluding embolism, the problem of thrombosis of the veins of the lower extremities is in itself formidable. Post thrombotic edema and ulceration cause much suffering and disability, and their treatment is often discouraging. In regard to embolism, it is a significant number of lives in studying thirty recent deaths d

that twenty five (83 per cent) of the deaths occurred without any apparent warning. De Takats has found that 40 per cent of pulmonary embolisms occur without warning. In analyzing twenty-eight deaths due to pulmonary embolism on the Surgical Service of the Hospital of the University of Pennsylvania since 1940, the first evidence that thrombosis had occurred in twenty (71 per cent) of the patients was the occurrence of the embolism which caused death.

Ochsner¹⁷ believes "that most, if not all, cases of intravenous clotting can be prevented by the institution of appropriate prophylactic measures." Many others share this enthusiasm regarding the effectiveness of prophylaxis, although there is not universal agreement concerning the value of various prophylactic measures. Among the measures proposed and in common use are exercise in bed, with and without special apparatus, frequent change of position in bed, avoidance of positions in bed which cause kinking of the popliteal and iliac veins, carbon dioxide inhalations, abstinence from tobacco during the pre- and postoperative periods, wearing of elastic stockings or bandages pre- and postoperatively, elevation of the foot of the bed, elevation of the head of the bed, application of heat to the lower extremities, or to various parts of the body, to produce reflex vasodilatation, the use of digitalis and various cardiac stimulants, correction of anemia and dehydration, weight reduction in the obese, gentle "atraumatic" operative technic, with the use of nonabsorbable ligatures and sutures, avoidance of abdominal compression bandages and binders, prevention and energetic treatment of abdominal distention, and the use of thyroid extract. Many of these measures have supposedly been shown by statistical studies, often of doubtful significance, to lower the incidence of thrombosis and embolism, and many are currently in use in surgical clinics throughout the world.

In addition to the above, three other prophylactic measures are under investigation at present on a wide scale. These are (1) early ambulation, (2) the use of anticoagulants, and (3) proximal vein ligation.

Early Ambulation.—Advocates of early ambulation, in which the patient is got out of bed on the operative or first postoperative day, or early in the postoperative period, point to the fact that thrombosis and embolism rarely occur in persons who are not confined to bed by an operation or illness. Use of this technic in surgical clinics is not new. Since the first report by Ries¹⁸ in 1899, the value of early postoperative rising has been extensively studied in Europe and in this country. Ochsner¹³ reports that at the Essinger University Clinic, from 1906 to 1912, when patients were got out of bed at the end of the second week, the incidences of postoperative thrombosis and fatal embolism were 2.63 and 1.4 per cent, respectively. At the same clinic, from 1912 to 1918, when patients were got out of bed between the second and fifth day, the incidences were reduced to 1.75 and 0.6

per cent, respectively Von Jaschke²¹ found that after the institution of early ambulation the incidence of thromboses and fatal embolism was reduced from 2 per cent and 1 per cent to 0.5 per cent and zero. Zava,²² using early ambulation in postoperative patients, many of

tical studies of methods of prophylaxis and treatment.

If we assume from Zava's experience that embolism may be expected in less than one in 6000 patients as the result of early ambulation, the superiority of any other prophylactic method will obviously have to be proved by many thousands of patients. Among others who have recently studied the incidence of thromboembolic disease in patients rising early in the postoperative period are Leithauser,²³ Nelson,²⁴ Powers,²⁵ and D'Ingianni.²⁶ Blodgett and Beattie²⁷ found the incidence of deep leg thrombophlebitis to be somewhat greater in an early rising group of patients as compared with a late rising group. Various opinions regarding the effectiveness of early ambulation have recently been reviewed by Newburger.²⁸

Anticoagulants.—The use of anticoagulants is based on the belief, discussed previously, that under certain conditions the coagulability of

fat
their prophylactic use in conditions known to be accompanied most frequently by intravascular clotting. Among the principal advocates of anticoagulants are Barker and his associates at the Mayo Clinic, who have used dicumarol in more than 1000 patients²⁹ "for the purpose of preventing postoperative venous thrombosis, pulmonary embolism, and thrombophlebitis." Dicumarol was given prophylactically, for example, to 438 patients who had not had previous thrombophlebitis or embolism, beginning on the second day after abdominal hysterectomy. In two patients thrombophlebitis developed in veins of the calf of the leg after the patient's discharge from the hospital, when the prothrombin had returned to normal, and none had emboli. In a control group postoperative thrombophlebitis and embolism occurred in 4 per cent and fatal embolism in 0.7 per cent after this operation. As opposed to venous ligation, the use of anticoagulants is believed to be the prophylactic measure of choice because thrombosis is prevented throughout the body, additional surgical procedures are not required, and

lower extremities
extensively a
in their mode of action, and each of these agents has certain limitations and advantages

Heparin.—The anticoagulant properties of heparin were first noted

in 1916 by J. MacLean, a medical student studying the thromboplastic behavior of several phosphatides in Howell's laboratory. Extensive studies of the heparphosphatide with which he was dealing were subsequently made by Howell, who proposed the name "heparin" to denote its origin in the liver. In 1933 Charles and Scott of the Connaught Laboratories in Toronto, working on the purification of heparin, succeeded in obtaining a crystalline barium salt from ox lung. In the same year Schmitz and Fischer, working independently in Copenhagen, obtained a pure brucine salt. The extensive experimental and clinical studies which followed the purification of heparin have recently been reviewed by D'Alessandro.³² The use of heparin in vascular surgery and in other conditions has previously been reported from this clinic.^{33, 34} The anticoagulant effect of heparin is demonstrable both in vitro and in vivo. Despite controversial opinions among experts in this field, it is the opinion of the majority that heparin acts both as an antiprotease and, with a component of the serum-albumin fraction, as an antithrombin. In addition, there is evidence that it may affect the liberation of thrombokinase from platelets.

The chief disadvantages of heparin have been its high cost and the necessity for continuous or frequent parenteral administration to maintain persistent elevation of the clotting time. In this clinic Walker and Rhoads³⁵ have shown, however, that the complementary effect of heparin and dicumarol make it feasible to reduce the amount of heparin required. In dicumarinized patients, with a prothrombin time of 20 to 30 per cent of normal, intramuscular injections of heparin at intervals of eight to twelve hours result in a prolonged and evenly maintained elevation of the coagulation time.

Loewe³⁶ and his co-workers have recently advocated the subcutaneous administration of heparin in Pitkin's menstruum, which delays absorption. A single subcutaneous injection of 300 mg. of heparin in Pitkin's menstruum has been found in most instances to cause elevation of the coagulation time for forty-eight hours. "Satisfactory results have been attained over protracted periods (five weeks) with as little as 2300 mg. of heparin. At least 10,500 mg. would have been required to achieve the same results with intravenous commercial, aqueous heparin had it been feasible to administer it over such a long space of time." One of the principal advantages of heparin over dicumarol is the simplicity of the laboratory test for its control—the modified Lee-White method. The neutralization of the anticoagulant effect of heparin by protamine in approximately stoichiometric proportions is a tremendous advantage in restoring the normal clotting mechanism if hemorrhage occurs. The toxicity of protamine if given in large amounts must be remembered, however.

Dicumarol.—The isolation and crystallization of the active principle in spoiled sweet clover that causes hemorrhagic disease in cattle were accomplished in the brilliant classical experiments of Link and his

associates^{31 38 39 40} Synthesis of the substance 3,3-methylene (4-hydroxycoumarin), identical in biological characteristics with the crystalline active principle, was then carried out. Its occurrence in nature had not previously been recorded. Although the exact mode of action of dicumarol is not known, its It is active only in vivo. The creased until the prothrombin normal. The decreased tendency of thrombus formation at prothrombin levels which are accompanied by only slight prolongation of coagulation time is not well understood, and the anticoagulant effect of various levels of hypoprothrombinemia is not definitely known. For clinical effectiveness, Barker and his co-workers²⁹ believe that the prothrombin time should be maintained between 10 and 30 per cent of normal.

Among the chief advantages of dicumarol over heparin are its low cost and oral administration. An outstanding disadvantage is the complicated laboratory test required for its control. This test—determination of the prothrombin time—must be performed at least once daily on patients receiving dicumarol. Accuracy in performance of the test is of the greatest importance, requiring a reliable and well trained technician. The need for constant control determinations on the thromboplastin used has been emphasized by Barker and by Brambel.⁴¹

Another disadvantage is the unpredictability of prothrombin response because of the apparent sensitivity of certain individuals. Barker, for example, found that in 93 (27 per cent) of 340 consecutive patients the prothrombin fell to less than 10 per cent, a level at which fatal hemorrhage may occur. Using the usual dosage plan of 300 mg the first day, 200 mg the second day, and 100 mg on subsequent days, prothrombin is usually not depressed to levels considered effective for from forty eight to seventy-two hours. During this latent period heparin may be used to obtain immediate prolongation of the coagulation time when this is desirable, e.g., in nonfatal pulmonary embolism. If bleeding occurs, the anticoagulant effect of dicumarol may be controlled by the administration of large amounts of vitamin K (60 to 75 mg) and by transfusions of fresh, whole blood. A recent study⁴¹ emphasizes that these measures are not immediately effective and that death from hemorrhage may occur before control measures can be instituted.

The effectiveness of anticoagulants in preventing thrombus formation is well established. Also, there is considerable evidence that they may limit the propagation of thrombi. In clinical application, however, they do not always prevent detachment of thrombi and pulmonary embolism. In this clinic two patients have had fatal emboli while under anticoagulant therapy. One was fully heparinized, while the other was receiving both heparin and dicumarol, with presumably protective levels of prothrombin and coagulation times. A number of

reports of similar experiences have appeared in the recent literature. Finally, the danger of hemorrhage, even when anticoagulants are carefully controlled, cannot be ignored. A number of deaths from hemorrhage have been reported, and undoubtedly many have not been reported. Until safer methods of using anticoagulants are found it may be well to question, in individual instances, whether the danger of pulmonary embolism is significantly greater than the danger of hemorrhage.

Proximal Vein Ligation.—The surgical approach to the prophylaxis of pulmonary embolism was initiated in this country by Homans⁴³ and has since been extensively studied by Welch and Faxon,³ de Takats,⁴⁴ Bancroft,⁴⁵ Allen and his associates,⁴⁶ and others. It is based upon the conviction that the majority of embolisms (95 per cent) arise from the veins of the lower extremities and can be prevented by interruption of the venous channels proximal to the site of thrombus formation. Although unilateral ligations were done at first, it has since become apparent that the frequency of bilateral involvement in phlebothrombosis requires bilateral ligation to prevent an embolism from arising from the contralateral leg. The preferred site for ligation, at which the operation is simplest and is followed by the least postoperative edema, is the superficial femoral vein just below the profunda femoris. At this point a segment of vein without branches may be easily exposed, with removal of floating thrombi, if present, followed by ligation.

Ligation of the common femoral vein, which has been advocated because of emboli arising from the profunda femoris, has been found to be followed by troublesome and prolonged edema in a high percentage of instances, and even by serious interference with circulatory return. In addition, Allen⁴⁶ feels that the probable added protection in common femoral ligation does not warrant the increased technical difficulties. Ligations of the common iliac veins, although more difficult and hazardous, have been performed by Homans⁴⁷ and his associates, who believe this procedure is advisable when proximal extension of the thrombus requires it. Ligation of the common iliacs, as Homans points out, may be done extraperitoneally as in the procedure commonly used to expose the ureters at the point where they cross the pelvic brim. In exposing the vena cava the approach is the same as for the right common iliac vein, with further reflection of the peritoneum upward and medially. Because of the danger of tearing these large veins during mobilization, ligation in continuity is safer than ligation and division. Homans believes that vena cava ligation is "probably indicated in the presence of bilateral thrombosis which is believed to have risen in the main venous system, on both sides, to or about the level of the inguinal ligaments." Of fourteen patients subjected to vena cava ligations by Linton, two developed postphlebotic edema with ulcer.

In femoral vein interruptions performed by Allen and his associates in 861 patients there have been no deaths.

procedure. In fact, the patient has therefore

an effective measure for preventing pulmonary embolism. The possibility that embolism may still arise from thrombi forming proximal to the site of ligation or from elsewhere in the body is of course not excluded. About 6 per cent of patients having nonfatal emboli prior to ligation continued to have infarcts after ligation and in one instance a fatal embolism occurred. This apparently came from the profunda femoris after superficial femoral ligation.

In addition to ligations performed in the presence of diagnosable or strongly suspected thromboembolism Allen and his associates have done approximately 100 purely prophylactic ligations in circumstances known to be associated with relatively frequent thromboembolic complications e.g. elderly patients with hip fractures.

SUMMARY

The predominance of venous thrombosis of the lower extremities and subsequent pulmonary embolism in middle aged and elderly patients is becoming increasingly recognized. The occurrence of these complications as commonly in so called "medical diseases" as following surgical operations is a challenge to all physicians who treat patients in the latter half of life. The syndrome of chronic venous insufficiency following thrombosis of the lower extremities is common causing much suffering and disability. Although pulmonary embolism causes only 5 per cent of postoperative deaths these often occur under tragic circumstances in which convalescence from a successful surgical procedure has been uneventful and there is great hope for relief of the symptoms which brought the patient to the hospital.

Of the many diverse factors which have been shown to predispose to intravascular clotting two appear to be of preeminent importance since they coexist in more than 80 per cent of all embolisms. These are (1) the age of the patient is above 40 and (2) the patient has been confined to bed by illness or operation. Since the treatment of thrombosis and its associated symptoms is far from satisfactory and there can be little assurance of a successful outcome once embolism has occurred the logical approach to these problems is prophylactic.

Many prophylactic measures have been proposed and are in wide spread current use with good evidence that they are effective. Three prophylactic measures which are under investigation at present on a wide scale each of which has strong advocates are early ambulation, the use of anticoagulants and proximal vein ligation. Although each of these measures is of undoubted value and warrants the enthusiasm

of its proponents, the statistical evidence available at present does not establish a clear-cut superiority of any one over the others. Moreover, the use of any one or any combination of these measures does not assure protection in all instances. It is of importance at present to bear in mind that each of these measures represents a fundamentally different approach to thrombosis and embolism. Current studies offer encouragement that many of the baffling problems of venous thrombosis and pulmonary embolism may be solved.

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THE HEALING OF WOUNDS

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Poor wound healing still occurs in patients in whom the original operative technic has been faultless according to modern concepts of surgical technic. Emphasis has been placed on the importance of asepsis, the gentle handling of tissues, the use of fine suture material, excision of all devitalized tissue, the preservation of the local blood supply, and many other factors applicable to local conditions in the wound. Ever

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requires not only meticulous operative technic but rigorous care especially in regard to the general condition of the patient.

There has been a tendency to regard complications of wounds, even wound dehiscence, as inevitable in a certain percentage of patients. In the light of recent studies, most wound healing complications are avoidable. For adequate management of wounds it is necessary to have a working knowledge of (1) the basic histology of tissue repair, including the repair of special tissues; (2) the factors which influence wound healing; (3) the unfavorable influence of certain biochemical changes as produced by various disease conditions; (4) the correction of these biochemical changes; and (5) the effect of various types of preparations commonly used in the local treatment of wounds.

NORMAL WOUND HEALING

Healing by primary intention the simplest type of wound healing is best illustrated by the healing of a simple incision. Immediately after injury, escaping blood, serum, and lymph coagulate to form the coagulum, a dense fibrin network which is filled mainly with erythrocytes and leukocytes. The coagulum may be considered to be a scaffolding which temporarily unites the edges of the wound. A type of inflammation, commonly referred to as traumatic inflammation, rapidly develops after injury. There is hyperemia, exudation, and leukocyte immigration in the surrounding tissues, phagocytosis, and enzymatic digestion of devitalized tissue. The increased number of cells observed in the area of traumatic inflammation probably serves as a defense against infection as well as for the removal of dead tissue.

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Digestion of necrotic material occurs partially by autolysis, by enzymes formed from the injured cells themselves in the form of pepsinase, peptase, arginase and the like. Heterolysis occurs mainly by reason of the leukocytic enzyme, leukotryptase, which under alkaline conditions digests dead tissue but cannot attack living cells or unchanged connective tissue fibers. As early as the third day of wound healing new vascular sprouts are present. The processes described dominate the picture of wound healing for from three to five days after injury. This phase of wound healing, the so-called *lag phase*, may be referred to as the preparatory period to the phase of active tissue regeneration, the phase of fibroplasia which follows.

During the *phase of fibroplasia*, which begins three to five days after injury, the fibroblasts grow through and along the fibrin network of the coagulum. They originate, divide and achieve maturity in direct continuity with the edges of the wound. Simultaneously there is vascularization of the coagulum. The connective tissue fibrils appear at first as separate delicate fibrils which rapidly increase in number and become firm. Harvey¹ has shown that the velocity of fibroblastic growth begins directly at a maximum and progressively diminishes in rate and that the tensile strength of a wound is the function of the multiplication and maturation of the fibroblasts within the wound. He believes that the other cells involved are relatively unimportant as far as tensile strength is concerned. There is little or no increase in tensile strength during the lag phase. The phase of fibroplasia is usually complete ten to fourteen days after injury.

The final phase of wound healing is the *phase of contraction* which may continue for an indefinite period, often for as long as a year. During this phase the scar tissue becomes more compact and less cellular. The vascular branches are squeezed until many of them are obliterated. Occasionally the phase of fibroplasia is not terminated in the usual period of time and the proliferating fibroblasts continue to reproduce until a keloid is formed.

Usually wound healing is described as healing by (1) primary intention (primary suture where sutures are used); (2) delayed primary suture (this term has been suggested by E. D. Churchill as contrasted with the term "secondary suture"); (3) healing by second intention and (4) healing by third intention or secondary suture. Healing by primary intention is the type of healing described in the previous paragraphs. When a great deal of tissue is lost by trauma or by infection or when the tissue edges are widely separated as by failure of a wound to heal primarily, the delayed healing which results is called healing by second intention. Contaminated traumatic wounds are often left open for four to ten days and then are sutured, the so-called delayed primary suture. A wound which has failed to heal by primary suture and which is again sutured and becomes healed, is said to have healed by secondary suture or third intention.

THE HEALING OF SPECIAL TISSUES

Skin.—Healing of the skin may be very rapid. If the cut edges of a wound are closely approximated, repair may be completed by the end of the first day. In large wounds epithelization may require a number of days, but there are evidences of epithelial cell migration evident sometimes within an hour after trauma. The epidermis resolves itself into a homogenous syncytial layer with many dark nuclei, and this syncytial layer penetrates beneath the surface of the coagulum or crust, as by enzymatic action. Beneath this syncytial layer, cells of the malpighian layer advance in the form of a wedge. When the crust or scab finally separates, the cleavage plane is through the syncytial layer, thus leaving a newly formed epidermal layer intact. A fully healed scar of epithelium is usually recognized as such because of its fibrous nature. It does not have cutaneous glands and hair follicles, and it fails to reform typical dermal papillae. Elastic fibers may or may not be present in epithelial scars. The appearance of elastic fibers, if they are to appear, may vary from thirty six days to nine months after the wound has otherwise healed. Pigment usually develops in the scar incompletely or not at all.

Muscle.—Muscle cells do not take part in the active process of tissue regeneration. Muscle defects are finally closed with bridges of fibrous tissue. All necrotic or severely damaged muscle therefore should be removed as its presence will only retard wound healing and increase the amount of the cicatrix or scar tissue.

Tendon.—Following division of a tendon a coagulum fills the space between the separated ends of the tendon. After a lag period of from four to five days the fibroblasts proliferate to form a fusiform structure which grossly resembles the callus formation in a fractured bone. Later the new fibroblastic tissue becomes relatively avascular, and the connective tissue fibers become arranged longitudinally as is characteristic of normal tendon tissue. If the gap between the cut ends of a tendon is not too great, the defect may be bridged by tendon cells in about two weeks. If the mesotendon has been preserved and the vascular supply of the mesotendon is not impaired the repaired tendon will remain movable in the tendon sheath. If however, the mesotendon is destroyed or if its blood supply is impaired so that the blood supply must come from the tendon sheath and surrounding tissues, there results a variable degree of fixation of the tendon to the surrounding tissues with consequent loss of function. Mason¹ has demonstrated a decline in tensile strength of sutured tendons during the first five days after injury. This is followed by a rapid increase in strength which reaches a plateau about the sixteenth day. From the nineteenth to the twenty first day there is further increase in tensile strength. On the basis of his experimental data Mason recommends that the restricted use of a repaired tendon start two weeks after injury and continue for one or two weeks. Such a program leads to a rapid increase in

tensile strength with only a slight increase in the reaction of tissue. Active motion, on the other hand, leads to increased tissue reaction and occasional stretching of the tendon, even at the end of three weeks.

Bone.—The preliminary stages of bone healing are much the same as in the healing of soft tissue. The proliferation of the connective tissue is from the endosteum, the periosteum and haversian canals. Osteoblasts from the periosteum and endosteum form fibrils which extend in all directions and these fibrils, as well as the cells themselves, become embedded in a homogeneous matrix. When calcium salts are deposited in this matrix, callus is said to be present. This calcium then undergoes partial absorption by the action of osteoblasts and new firm bone with a characteristic bone pattern is laid down by the osteoblasts. The superfluous external callus is reabsorbed until the normal contour of bone is restored.

Nerve.—When a peripheral nerve is divided, it goes through the process of wallerian degeneration in which the nerve axons or fibrils break up into granular fragments. The myelin sheaths undergo chemical changes to form irregular fatty globules in the tissues. Finally, the degenerated fibrils and myelin are entirely absorbed. The neurilemma cells show an increase in protoplasm and form nucleated protoplasmic bands. There is also proliferation of the perineurium. The end result is a bandlike structure which acts as a receptacle for the regenerating proximal nerve ends. Regeneration of nerves may continue for a considerable period of time. Holmes and Young³ in experimental work have shown that the rate of regeneration of nerves decreases considerably after one hundred days, presumably because the denseness of the surrounding scar tissue prevents rapid penetration of the regenerating nerves. This experimental evidence emphasizes the clinical observation that nerve suture should be done as early as possible. Zachary and Holmes⁴ have stated that probably the best method of handling divided nerves in traumatic injuries is by delayed primary suture.

Intestinal Tissues.—The healing of intestinal wounds is by a manner similar to that of other soft tissue wounds. There is rapid healing of the serosal surfaces, and the mucosal regeneration is much more rapid than in any other epithelial tissue. In the repair of intestinal defects it is important that the serosal surfaces be in contact so that a watertight seal can be formed as rapidly as possible. A healed wound of the intestinal mucous membrane may in every way resemble the normal tissue. There may be very little scar tissue and little or no contraction.

FACTORS IN WOUND HEALING

Protein Intake.—In any attempt to evaluate the condition of a given patient in regard to the probability of healing of wounds, one must

consider the patient's state of **nutrition**, especially in regard to protein intake. Since Thompson, Ravdin and Frank⁵ first demonstrated that wound healing was delayed and that some wounds failed to heal in



Fig. 529.—A Wound healing in a hypoproteinemic dog. Complete disruption of experimental wound at the end of two weeks. B Normal wound healing of control animal. C Muscle fibers widely separated with edema fluid in a hypoproteinemic animal.

the presence of hypoproteinemia studies of patients with wound disruption have confirmed the experimental observation that serious protein deficiency may be a factor in poor wound healing^{6, 7} (Fig. 529)

Rhoads and Kasinskas⁸ have shown a delay in the healing of experimental fractures in the presence of hypoproteinemia. The rate of healing of abdominal wounds and the rate of healing of bone is restored to normal velocity when the serum protein is restored to normal levels.⁸⁻⁹ When protein metabolism is disturbed as by a sterile soft tissue abscess or an infection elsewhere in the body, tissue regeneration in wounds is retarded.¹⁰⁻¹¹ The draining of a sterile abscess or the disappearance of infection at a distant site is often followed by a return of the normal velocity of wound healing. When food can be given by mouth and utilized, 2 to 3 gm of protein per kilogram daily will supply the daily protein requirements and correct existing protein deficiencies provided the total calorie intake is adequate. The administration of 375 gm of protein daily for ten days will elevate a serum protein level 2 gm per 100 cc in ten days according to the calculations of Elman.¹² When the patient is not able to ingest adequate oral feedings, intravenous injections of blood, plasma and protein hydrolysates are indicated, but it must be remembered that the intravenous use of any of these substances is not a satisfactory substitute for an adequate diet by mouth.

Vitamin Intake.—After the first clinical studies by Aschoff in 1919 on the relation of vitamin C to wound healing, a wealth of data has confirmed the necessity of vitamin C for the maturation of precollagen into the collagen of connective tissue fibers and, therefore, the necessity of vitamin A for the healing of all but a few types of tissue. The amount of intercellular substance formed in healing tissues is in direct proportion to the amount of vitamin C available.⁴³ It is not generally realized that many outwardly normal patients have subnormal plasma vitamin C levels and that not a few are actually bordering on a state of scurvy. Of one hundred and twenty four medical students studied by Holman¹³ as a representative group of controls, he found that thirty-two of these students had abnormally low plasma vitamin C levels and that three of the group had levels compatible with clinical scurvy. So, too, it is little realized that many commonly encountered surgical conditions are associated with deficiencies of vitamin C. Of one hundred and eighty-eight consecutive hospital patients studied by Bartlett, Jones and Ryan,¹⁴ two thirds had plasma vitamin C levels below the normal range. The average patient with hyperthyroidism, severe burns, severe traumatic injury, carcinoma of the gastrointestinal tract, peptic ulcer, chronic sepsis and chronic diarrhea have plasma vitamin C levels which are below the lower limit of the average normal range of plasma vitamin C.¹⁴⁻¹⁵⁻¹⁶⁻¹⁷ A fall in the circulating vitamin C has been found after the use of various anesthetic agents.¹⁸⁻¹⁹ Lund and Crandon²⁰ believe that 1 to 4 gm of vitamin C with 30 mg of thiamine hydrochloride and 100 mg of nicotinic acid should be given daily for four days before operation to patients suspected or known to have a vitamin C deficiency. A vitamin C de-

iciency with resultant increased capillary fragility may also predispose to hemorrhage from the surfaces of a wound

Deficiency of vitamin K may interfere with normal of blood and the consequent lesions which in turn predispose to infection and wound separation. Borgstrom²¹ has shown a decrease of circulating prothrombin in the blood following operation and the use of certain types of anesthetic agents. Hypoprothrombinemia is prevented by 1 to 3 mg. of one of the various synthetic vitamin K preparations together with bile salts orally daily for two to three days. If the patient is unable to take oral medication a water soluble preparation for parenteral use should be administered.

The experimental results in the literature on the effects of deficiencies of vitamins A, D and the B complex on the wound healing are conflicting. It is known however that deficiencies of the vitamins A, D, C, thiamine, riboflavin and pantothenic acid lower the rate of phagocytosis and bacterial digestion. Thus deficiencies of these vitamins might predispose to local wound infection by reducing the efficiency of the defense mechanism of the body against bacterial invasion. If deficiencies are suspected or known to be present the most direct method of treatment would be the systemic administration of the vitamins rather than topical administration to the wound surfaces.

Electrolyte and Water Balance—Alterations of the normal electrolyte balance and normal water balance do alter the rate of wound healing. Dehydration leads to a prolongation of the lag phase and a delay of wound healing.² Experience has shown that wounds tend to heal poorly in the presence of edema. Ravdin and others have repeatedly stressed the fact that edema may become evident when the serum protein level begins to fall below the normal average of 7 gm. per 100 cc. It is not necessary for the serum protein level to fall to the so called "critical level" of 5.5 gm. per 100 cc. before clinical edema develops. Recently Keys and his associates²⁴ have demonstrated in a group of malnourished individuals that the plasma protein level need be reduced only 0.73 g. before obvious clinical effects. Winkler²⁵ state that alkalosis prolongs the rate of wound healing.

Anemia—Although the adverse effect of anemia on wound healing has been repeatedly stated in the literature there is but one report in the literature designed to prove or disprove this observation. Besser and Ehrenhaft²⁷ have shown that anemia alone has no effect upon the tensile strength or the histological structure of healing wounds of the stomach of the dog. It is possible that the delayed wound healing observed in many anemic patients may be due to faulty electrolyte

balance, faulty fluid balance, nutritional disorders or combinations of these factors with the observed anemia

Local Temperature.—Variations in local temperature have a decided effect upon tissue regeneration. An increase in the rate of tissue repair has been noted clinically following sympathectomy and the application of thermal heat in the presence of certain vascular conditions²⁹. The favorable results are presumably due to the hyperemia and the increased temperatures of the affected parts. The rate of tissue repair increases with increases in temperature in experimental animals. Ebcling²⁹ found in alligators that the rate of wound healing was doubled for each ten degrees rise in the body temperature of the animals.

Conversely, it would appear that a decrease in temperature as by refrigeration would retard wound healing. Large and Heinbecker,³⁰ using refrigeration of the extremities of the dog, found a definite lag in the healing of wounds, the degree of delay varying with the duration of the cooling period. They also report a greater number of infections in the cooled extremities as compared with wounds in uncooled extremities. Bruneau and Heinbecker³¹ have shown that refrigeration of an extremity does not have a beneficial influence upon the infectious process per se. Clinically, however, it is well recognized that cooling of an infected extremity in preparation for amputation will reduce systemic toxicity, presumably due to the reduced blood flow and the decreased metabolic rate of the tissue and the infecting organisms. The delayed healing observed by Large and Heinbecker raises the question as to whether or not one ought to refrigerate an extremity as high as the site of an amputation as is done in the use of refrigeration anesthesia.

Miscellaneous Factors.—The rate of wound healing decreases as the age of the patient increases. It is also known that the velocity of wound healing varies with the size of the wound. The larger the wound the greater the initial velocity of wound healing. As the wound heals and becomes smaller the velocity decreases. The importance of infection, further trauma and preservation of blood supply are well recognized and, therefore, will not be discussed further.

STATUS OF WOUND HEALING STIMULANTS

Patients often have great faith in the doctor's ability to "heal wounds" by the application of topical agents. What can be done to accelerate wound healing in the normal patient in the absence of infection? The reports of the effect of various forms of radiant energy are conflicting. Thyroxin, insulin and other extracts and tissue preparations of the endocrine glands have been extensively investigated.³² Chlorophyll ointment, cod liver oil, commercial vitamin A and D ointment, balsam of Peru, various vitamins other than C and K, irradiated petrolatum, allantoin, chloramine paste, tals, glycerin, pectin solutions, biotin, hydrosulphosol,

sulfathiazole glycerin adenosine and liver extract have been found by competent investigators not to have a stimulative effect on wound healing^{33 34 35} Mandl³⁶ has reported excellent results with the use of adult tissue extracts and Schaeffer³⁷ has reported encouraging results with amino acid preparations while Andrus and Hoffman³⁸ have recently reported encouraging results following the use of an embryonal extract. These agents will require further investigation of their beneficial effect upon wound healing. Although numerous reports appear in the literature of the accelerating effect of a great number of topical agents *the fact remains that there is no generally accepted and proven agent or treatment for accelerating wound healing beyond the normal rate of healing.* The emphasis should be placed on restoring and maintaining a normal physiological state of the body in general preventing invasive infection by the use of systemically administered antibiotics or sulfonamides and adequate drainage of purulent collections already present. When using the various ointments and other agents prepared for the local treatment of wounds one should remember that they can in no way be considered substitutes for accepted wound care.

WOUND CONTAMINATION AND INFECTION

Experience gained in the various theaters of World War II demonstrated that the mere presence of bacteria even in large numbers on the surface of a wound did not necessarily indicate that the wound was infected in the traditional sense³⁹. It was learned that open wounds free of necrotic material loculated purulent collections and surrounding cellulitis could be safely closed secondarily when lined with healthy granulation tissue regardless of the number of or type of bacteria present on the surface of the wound. It would seem in the light of this finding and findings of Anderson⁴⁰ who initially made this observation that the definition of wound infection should not simply imply the presence of bacteria in an otherwise clean wound. In a strict sense a wound infection is present when there is either evidence of systemic toxicity as usually manifested by leukocytosis and elevation of body temperature or local changes as evidenced by necrosis and cellulitis.

ANTISEPTICS AND WOUND HEALING

Many chemicals chiefly dye substances and antiseptics have been reported to influence wound healing favorably by their antibacterial effect. One of the *most carefully controlled studies of the effect of various agents on the rate of wound healing and the number of surface bacteria* is that of Anderson⁴⁰ who anticipated the relative unimportance of surface bacteria as was clinically proved by recent war experiences³⁹. He stated that in the absence of invasive infection (progressive cellulitis or necrosis) and in the presence of adequate drainage the rate of wound healing as calculated from the size of

the wound and the age of the patient, was unaltered by any of the antiseptic agents which he used. Anderson and others^{33 34 40 41} found no beneficial effect upon wound healing of the use of merthiolate, mercurochrome, azochloramide, zinc peroxide, irradiated petroleum, thiocresol, allantoin, chloramine paste, sodium chloride solution or Peruvian balsam. Figure 530 shows that even though azochloramide effectively reduced the relative number of bacteria present in a wound,

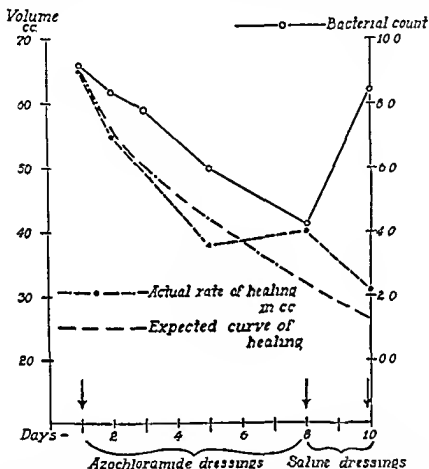


Fig 530—The use of azochloramide dressings in this instance reduced the number of bacteria on the surface of the wound. The observed rate of healing closely approximates the calculated rate of healing even when the azochloramide is discontinued.

the actual rate of wound healing was not significantly influenced when it was compared with the expected rate of regeneration as calculated by the formula of du Nouy⁴², Lambert and Meyer,⁴¹ German,⁴³ Buchsbaum and Bloom⁴⁴ and Salle and Lazarus,⁴⁵ although they did not use identical technics. They agreed that every antiseptic they tested had a more deleterious effect on tissues than on bacteria. Anderson suggested that the continued usefulness of chlorine antiseptics over so many years was due to their ability to assist in the separation and solution of necrotic

tissues in infected wounds. Once the necrotic tissues were removed, the local surface infection was of little clinical significance.

It is becoming more and more apparent that *sulfonamides* applied locally to soft tissue wounds do not reduce the incidence of local wound infections.^{46 47} The reason for the failure of sulfonamides to reduce local infection may be due to two known factors. The sulfonamides generally are most effective against gram positive organisms and, therefore, are less effective in mixed gram positive and gram-negative infections. Also, it is a well known fact that the effectiveness of the sulfonamides when applied locally is greatly diminished by the presence of serum, necrotic tissue and purulent material. That they reduce the incidence of invasive infection under such circumstances is highly likely. *Penicillin* is also largely limited in its usefulness to the gram positive organisms and it is destroyed by the products of certain bacteria. The action of penicillin is, therefore, very limited in the treatment of mixed wound infections.

The present usefulness of penicillin and the sulfonamides lies mainly in their ability to prevent blood stream, lymphatic, and cellular invasion, and thus prevent the complications of local wound infection, lymphangitis, lymphadenitis, cellulitis and septicemia.

ANTISEPTICS AND TANNING AGENTS IN THE TREATMENT OF BURNS

Infection has long been recognized as one of the major causes of death of burned patients. In an effort to destroy bacteria and in an effort to seal the burned area, a number of antiseptics and tanning agents have been used to treat burns. It has been demonstrated by Baker⁴⁸ among others that many of these previously widely used agents cause further tissue damage. This further injury may lead to a poorer cosmetic result and to additional functional impairment and at the same time may produce more devitalized tissue in which bacteria can gain a foothold. Baker found that white soap, ether, benzene, hexylresorcinol, hydrogen peroxide, medicinal alcohol, tannic acid, silver nitrate and the "triple dye" cause some necrosis of wounds, and that isotonic physiological saline solution, petrolatum and ordinary motor oil cause no necrosis of wounds. The present trend in the treatment of burns is toward the use of simple petrolatum gauze, pressure dressings, and the systemic administration of sulfonamides or antibiotics.

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THE PATHOLOGIC PHYSIOLOGY OF INFECTION

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THE conquest of bacterial infection is developing into one of the most significant chapters in the history of medicine. Recognition of the etiologic significance of bacteria in many diseases provided the rational basis for control of contagion, and for antiseptic and aseptic surgery. The immunologic approach to infectious diseases then made noteworthy strides, effective methods of inoculation were developed, and a severe toll of human life was averted. The usefulness of protective and preventive measures in a few types of infections, advances were made in determining the chemical nature of antigens and antibodies and in providing biochemical interpretations of immunologic reactions. The most recent addition to this chapter has been the discovery, and wide use, of a variety of chemical substances which, when administered to the infected patient, act in some still obscure fashion to limit the ability of bacteria to survive as parasites within the patient host. The ability of the sulfonamides, penicillin and streptomycin thus to check the spread of invasive infection has been a factor of enormous assistance to the surgeon in treating the localized infections of soft tissues, bone and serous cavities which come within his sphere of special interest.

It is well, however, to call attention to the fact that most of the progress which has been made in this conquest of infection has been based on a philosophy of 'parasite extermination'—similar to that which is traditionally employed in meeting the menace of invasion of a community by a species of rodents. Comparatively little attention has been given to *physiological* aspects of infectious diseases—to those disturbances in biochemical equilibria which *result* from parasitic invasion of the host and which, in the last analysis, are of dominant importance in the morbid sequence and the outcome of infection. This shortcoming in our knowledge is not pointed out for the purpose of belittling what has been accomplished, bacteriemia from infection by the *Streptococcus hemolyticus* and the *Staphylococcus aureus* has now been eliminated as an inevitable cause of death without our ever having had to learn much about the characteristic abnormal physiologic sequences of these diseases. The need for greater knowledge of the pathologic physiology of infection is felt most acutely in our ap

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proach to types of infections in which disturbances in bodily function are so profound as to make inadequate the limited antibacterial attack, where the bacteria initiate chain reactions which can only be stopped short of a lethal outcome by timely application of rational physiologic treatment, and where the infecting agents cannot be brought under direct chemotherapeutic control

Two types of surgical infections* which fall into this category are peritonitis of intestinal origin and gas gangrene

EXPERIMENTAL WORK ON PERITONITIS

My interest in the physiologic aspects of acute infection has been greatly stimulated during the past few months through a systematic study of dogs which have been subjected to experimental appendiceal peritonitis^{1, 2} A program which was initiated primarily for the purpose of evaluating penicillin and streptomycin therapy of peritonitis has now turned into a pursuit of an explanation for the remarkable variations among dogs in their susceptibility to a type of infection which, when viewed as a purely *local* process, appears in most essential respects to be uniformly reproduced from animal to animal

Peritonitis was produced in a series of almost 200 dogs, by ligation of the base of the appendix, followed by the administration of a large dose of castor oil. Fluids sufficient to prevent acute dehydration were administered either orally or parenterally. The animals were then watched carefully until death, or for a ten day survival period, and frequent laboratory determinations of many varieties were carried out.

The reported observations which are especially pertinent to this discussion may be summarized as follows:

1. This disease is characterized by the development of a shocklike crisis at thirty six to fifty hours following application of the ligature. The crisis coincides in time with the development of a necrotic thin-walled fluid filled sac. In a series of over a hundred untreated controls, approximately one half of the animals have survived the crisis and recovered and one half have died. The bacterial flora of the peritoneal exudates in dying and surviving animals are qualitatively similar.

2. Laboratory studies in the two groups of animals have indicated that whether an individual animal dies or survives is determined by factors inherent in its "condition" at the time it is subjected to the operative procedure. The most reliable prognostic index, in advance of the onset of the crisis, is the stability of the prothrombin time during the first twenty four hours after operation. This suggests that the adequacy of liver function may be an important factor in prognosis.

3. Animals which died showed a marked disturbance in the equilib-

* The question may also be raised as to whether the approach to certain virus diseases might not be enhanced by supplementing the present attack on etiologic agents with more rationally developed physiologic concepts of "supportive" treatment.

rium existing between fibrinolytic and antifibrinolytic factors in the plasma leading to markedly increased fibrinolytic activity, usually paralleling the prolongation of prothrombin time

4 Evidences of a hemorrhagic diathesis were frequently observed at autopsy, involving intestinal mucosa and serosa, adrenals, liver and lungs

5 Statistically significant increases in survival have been recorded among the following groups of animals

(a) A group of fifteen animals which had been maintained on a well balanced diet in the laboratory for a period of many months (one death)

(b) A group of twelve animals injected with trypsin daily for twelve days before operation (Mortality 16.6 per cent as contrasted with 66.6 per cent in a parallel control series of twelve animals) Administration of trypsin was performed because of evidence that it increases the antifibrinolytic factor in plasma and thereby stabilizes the system which is strikingly deranged in dying control animals (See later discussion)

6 The administration of large doses of penicillin had no effect on survival

From these observations it has been inferred that survival of the dog from this type of peritonitis is largely determined by factors inherent in the animal at the outset of the disease. The animal survives if it is equipped to withstand the transient shock inducing effects of absorption of toxic products of appendiceal necrosis—effects which find their most clear cut expression in relation to factors involved in the clotting mechanism: prothrombin, fibrinogen, fibrinolysin and antifibrinolysin

In the treatment of peritonitis attention should be directed not alone at chemotherapy, which is at best of limited value in the established disease, but also toward measures designed to preserve the functional integrity of the liver, where prothrombin and fibrinogen are known to be produced. Since an adequate intake of protein and a continuous supply of well oxygenated blood are of vital importance in liver function, it would appear desirable to prevent even transient hypotension or anoxemia and to maintain an adequate intake of protein during the critical phase of the disease. It remains to be determined whether stabilization of the fibrinolysin antifibrinolysin equilibrium can be used as a rational basis for still other therapeutic procedures

This experimental work on peritonitis has been briefly reviewed in order to call attention to the potential usefulness of studying acute infectious diseases from the physiologic, as well as from the bacteriologic and pathologic, standpoints. It serves also to introduce the principal theme of this paper, namely, the role of infection as a causative factor in many instances of shock

INFECTION AS A CONTRIBUTING ETIOLOGIC FACTOR IN SHOCK

The term "shock" is used here in a very broad sense and connotes an acute maladjustment in the distribution of sufficient available oxygen in the blood to maintain the aerobic metabolism of critical organs of the body, particularly the liver, adrenals, kidneys and heart muscle. The initiating factor may be loss of blood volume below the amount required for maintenance of circulatory dynamics, as is usually the case in "surgical shock," but shock may also be caused by failure of cardiac muscle, by loss of peripheral vascular tonus, by failure of the mechanisms concerned in oxygenation of blood, or by an alteration in the composition or physical condition of the oxygen distributing apparatus—the blood itself. It is my belief that attempts to apply the term "shock" in a more restricted sense lead inevitably into indefensible ambiguities. This definition of shock allows for distinction between trauma and infection as *etiologic* factors, but encompasses the ultimate fundamental consequences of both.

The development of infection in association with severe blood loss from trauma and perforating wounds is known to be an important contributing factor in the development of the state of "irreversibility" in surgical shock. Under these conditions the restoration of amounts of blood in excess of the amount lost may prove to be incapable of raising the blood pressure to normal levels. Emerson and Ebert³ measured blood volume changes occurring in response to therapy in 112 nontransportable battle casualties in the European theater, and showed very clearly that shock, with intractable hypotension, would develop and persist in patients with peritonitis in spite of maintenance of normal blood volume. Five out of six fatalities among fifty five patients selected for study who had been admitted with blood pressure readings *above* 85 mm of mercury had perforated abdominal wounds and peritonitis. Peritonitis was an important contributing factor in eight out of the eighteen patients who died after admission in shock so severe as to exhibit admission blood pressure *below* 85 mm of mercury. Emerson and Ebert assign to peritonitis and gas bacillus infection an important role in perpetuating and aggravating shock, "*irrespective of a normal blood volume*".

Pope, Zamecnik, Aub, Brues, Dubos, Nathanson and Nutt⁴ analyzed the factors responsible for the type of shock induced in dogs through absorption of products of ischemic muscle. They concluded that bacterial contamination is the source of a "toxic factor" in experimental shock in dogs, and that the clostridia which are naturally occurring contaminants of living dog muscle begin to produce the "toxic factor" as soon as anaerobic conditions favorable to toxin production develop within the muscle. Although clostridia are not found in normal human muscle, they are present in a high percentage of severe accidental wounds⁵ and may be an aggravating factor in shock following wounds in which clinical evidence of gas gangrene may never appear. The

severity and significance of shock in established gas gangrene is well recognized. In this condition a vicious circle develops in which the anaerobic infection and the circulatory collapse are mutually aggravating factors. Mahoney, Howland and Yackel⁶ observed that shock produced in dogs from application of the Blalock crusher ran a more rapidly lethal course when the crushed extremity was experimentally infected with *Streptococcus hemolyticus* and *Clostridium welchii*. They, too, observed that the aggravation of shock produced by infection was not a result of increased loss of fluid in the infected animals, but was due to circulating products of bacterial activity in traumatized muscle.

In view of these evidences of the role of infection as an etiologic, or an aggravating factor in shock, it seems pertinent to consider some of the physiological mechanisms through which infection may enter into the cycle of shock. It may be repeated that this is not a field of investigation which has yet received the attention which it deserves, especially in relation to surgical infections, and it will therefore be necessary to enter into a few speculations in matters where only meager and incomplete experimental data are as yet available.

BACTERIAL TOXINS AS CAPILLARY POISONS

During recent years the physiologic effects of endotoxins present in protein fractions of many gram negative bacilli have been studied by several groups of investigators, including Penner and Bernheim⁷ and Morgan.⁸ The administration of Shiga toxin intravenously induced a profound shocklike state, characterized by a falling blood pressure and marked reduction in blood volume. Similar results occur if the toxin is absorbed through a closed intestinal loop, only the reaction is less precipitate. In erythrocyte count—very low; hematocrit—very low; with little or no profound loss of plasma into the tissues or a selective segregation of red cells in the larger vessels. Penner and Bernheim attribute the ulcerative changes which appear in the intestinal mucosa to the anatomic end result of a pronounced and prolonged homeostatic vasoconstriction of submucosal vessels, with resulting ischemia and necrosis of the mucosa itself. It is worthy of note that ulcerative changes in the intestinal mucosa have been noted in advanced shock of diverse origins. Morgan injected intravenously endotoxin derived from *Escherichia typhosa* and obtained similar results. In histopathological studies on animals dying of this type of intoxication he found widespread injury to capillary and blood vessel walls with subsequent thrombosis and resultant 'necrosis of cells of the liver, heart muscle, adrenal glands and bone marrow.'

Physiologic and histologic changes similar to those caused by puri-

fied endotoxins were regularly noted in animals dying of peritonitis in the experiments in this laboratory, to which previous reference has been made. There is general agreement that toxic protein fractions qualitatively similar to those in *Shigella dysenteriae* and *Eberthella typhosa* are present in all of the gram-negative bacilli, including *Escherichia coli*, the organism encountered with greatest frequency in the exudates of animals succumbing to experimental peritonitis. The shock-producing propensities of vascular poisons as powerful as those elaborated by these widely prevalent intestinal bacteria must certainly play an important role in the pathologic physiology of peritonitis in man. (It is not yet entirely clear whether the toxic action of these bacterial proteins is directed against the capillaries themselves, or whether the effect is mediated through the sympathetic nervous system (Zahl, Hutner and Cooper¹⁰)).

Recognition of the probable significance of the action of endotoxins of gram negative bacteria is not without important practical implications in treatment of the disease. It becomes of obvious importance to compensate for the loss of blood volume and the hemoconcentration induced by the disturbance in capillary function, the need for transfusions of blood and plasma in peritonitis is too well recognized to require further emphasis. However, there is reason to believe that the actions of these endotoxins may be combated directly with the use of chemotherapeutic agents. It has always been difficult to explain the apparent beneficial action of the sulfonamide drugs in peritonitis simply on the basis of their bacteriostatic action against the colon bacilli, nonhemolytic streptococci and anaerobic bacteria which abound in the infected peritoneum, the known resistance of these organisms to the effects of sulfonamides *in vitro* has prompted some clinicians to question the desirability of employing them in peritonitis with mixed bacterial flora. However, it has been demonstrated by several groups of investigators⁹ that the sulfonamides exercise a nonspecific protective action in animals against the lethal effects of endotoxins of gram negative bacteria. Zahl, Hutner and Cooper, for example, found that the majority of a group of mice which had been given sulfonamides by mouth would survive doses of Shiga toxin which were 100 per cent lethal for control mice. Being unable to demonstrate a direct action of the drugs on the toxin, they concluded that the sulfonamides acted in some nonspecific fashion to enhance the resistance of the animals to the action of the toxin. Of less immediate relevance to the problem of peritonitis is the more recent demonstration by Boor and Miller¹¹ of a similar protective action by penicillin against the lethal toxin of the meningococcus. These nonspecific effects of chemotherapeutic agents not only provide a rational basis for the continued employment of sulfonamides in the treatment of peritonitis, but also suggest an avenue of investigation which might lead to the discovery of even more powerful weapons to combat the toxemia of this disease.

BACTERIAL TOXINS AS SPECIFIC ENZYMES

An interesting instance of still another approach to the treatment of bacterial induced toxemia has been provided by Zamecnik Folch and Brewster¹² Having confirmed the fact that the alpha toxin of *Clostridium welchii* contains an enzyme lecithinase, which rapidly breaks down the lipid outer membranes of erythrocytes and other cells, causing hemolysis and cell destruction they administered intravenously nontoxic doses of lecithin and of crude extracts of cell lipids and found that animals so prepared would withstand several lethal doses of alpha toxin. The presumption is that in the presence of an excess of available lipid substrate, the action of the toxin is expended on the added substrate rather than on the cell membranes. Unfortunately, the action of absorbed toxin is so rapid that it is necessary to administer the lecithin compounds in advance of the dose of toxin in order to prevent intravascular hemolysis and cell destruction. This does not necessarily mean that the principle might not be of value in established gas gangrene, because the slowness of absorption of alpha toxin from the infected area would allow time for blocking the effects of toxin remaining to be absorbed.

PLASMA PROTEOLYTIC ENZYMES AND FIBRINOGEN

In the foregoing sections two examples of shock promoting effects of specific bacterial toxins have been cited together with brief mention of the methods of treatment appropriate for each which have been suggested in recent work. Attention may now be called to still another physiological system which we have found to be thrown out of balance as a result of infection, namely, the equilibrium between the plasma protease and its respective inhibitor.² The proteolytic enzyme which is normally available for activation in plasma and which is most readily demonstrated through its lytic action on fibrinogen and fibrin presumably remains for the most part in the form of an inactive precursor.¹³ However, just as is the case with pancreatic trypsin which it resembles, the plasma protease may become converted to its active form through contact with activators of bacterial and tissue origin. The so called "fibrinolysin" of the hemolytic streptococcus is in fact, merely an activator of the plasma proteolytic enzyme system.^{14, 15} and in conformity with conventional terminology, has been renamed "streptokinase".¹³ The action of the plasma protease is normally counterbalanced by a circulating inhibitor factor, corresponding to and closely resembling the pancreatic trypsin inhibitor. It has been thought that the amount of inhibitor normally present in plasma is in such excess of the amount required to neutralize available active protease as to prevent the lytic action of plasma protease on proteins with which it comes in contact. However, Grob¹⁶ has shown that raising the titer of protease inhibitor by repeated intramuscular injections or oral feeding of trypsin is accompanied by a marked increase in the

ability of animals to withstand the local digestion of tissues caused by subcutaneous injection of proteolytic enzymes of animal and bacterial origin. It was this finding which prompted Kay and me¹ to evaluate the protective influence of repeated trypsin injections against the lethal sequences of appendiceal peritonitis, with results which have already been briefly described.

We return to this topic for the purpose of considering some of the possible physiological consequences of a disturbance in equilibrium between proteolytic and antiproteolytic factors, with particular respect to effects of such an imbalance upon fibrinogen.

1 *Interference with the stability of fibrinogen*—One of the phenomena frequently observed in the terminal phases of severe shock is the absence of clotting of shed blood. Tagnon^{17, 18} has explained this as an expression of the loss of equilibrium between proteolytic and antiproteolytic factors in the plasma, and has induced profound shock, accompanied by marked reduction in fibrinogen and prothrombin concentrations, by the intravenous injection of trypsin. The dog which is moribund with peritonitis frequently displays not only a marked prolongation in clotting and prothrombin time values, but also shows a definite increase in the rate of spontaneous fibrinolysis, measured under standardized conditions.² The evidence suggests that the stability of the equilibrium between fibrinolytic and antifibrinolytic factors is a significant prognostic index of the probable outcome of the experimental disease in dogs. It is presumably this equilibrium which is stabilized by preparatory treatment with repeated injections of small doses of trypsin—but final clarification of this point has not yet been obtained.

2 *Interference with mechanisms of localization of infection*—The release of proteolytic and/or fibrinolytic enzymes at the local site of infection as well as within the circulation would seem to be capable of interfering very substantially with the formation of the fibrin barrier in the lymphatics and extravascular tissue spaces which is the first stage in the process of inflammatory fixation at the periphery of the infected area. It is possible that the higher survival of trypsinized animals in our series may be accounted for on the basis that more adequate neutralization of fibrinolysis results in more rapid fibrin deposition around the necrotic appendix. Autopsy findings on "trypsinized" dogs subjected to experimental peritonitis lend some support to this conjecture.

3 *Conglutination of erythrocytes (sludge)*—Knisely and his colleagues¹⁹ have described still another mechanism in the pathologic physiology of shock, relating to fibrinogen, which is of considerable interest to the student of infection. These workers have studied the pattern of flowing blood in the small mesenteric vessels, using strong transmitted light and high magnification, permitting direct observations as well as cinematographic recording. They find that even mild

crushing of a small area of the omentum results in the formation of intravascular clumps of erythrocytes in venules draining the periphery of the crushed area. They infer that this conglutination of erythrocytes, to which they assign the term *sludge*, is a consequence of the deposition of a sticky film of fibrin upon the cell surfaces, and that the reaction is caused by the liberation from the crushed area of substances capable of initiating the conversion of fibrinogen to fibrin.

When sludge formation is extensive, there results a marked alteration in the pattern of flow in small vessels and capillaries, the masses of clumped erythrocytes being incapable of passing through vessels possessing diameters little larger than that of an individual erythrocyte, and marked local stasis occurs. The mechanical impedance of blood flow is further aggravated by leakage of plasma through capillary walls proximal to a point of obstruction, so that the factor of hemoconcentration is superimposed on the already existing mechanical obstruction. Masses of sludged cells frequently break off into a moving current and are carried into the general circulation. On the other hand, they may become converted into adherent cellular thrombi causing obstruction of the involved vessels until recanalization takes place.

Knisely has observed evidence of sludge formation in a great variety of diseases, but has never observed it in normal animals or human subjects. Evidence has been advanced that the factor of sludging of blood is closely related to the morbid sequences of malaria and of severe burns, and it is quite possible that further investigation will disclose that it operates as a significant pathologic mechanism in peritonitis and other highly fatal infections. It has appeared that many of the observed phenomena of experimental peritonitis in the dog could be explained on the basis of such a process—including the rapidly rising hematocrit in venous blood, the increased sedimentation rate, and the venous stasis within the lung capillaries. However, the deposition of fibrin on erythrocytes, which is the presumptive basis of sludge formation, has been only indirectly related to alteration in the equilibrium between proteolytic and antiproteolytic factors in plasma. If such a correlation can be established, an interesting cycle of pathologic physiological phenomena will be opened up for direct therapeutic attack.

SUMMARY

The remarkable advances which have been made in the chemotherapeutic and immunologic approaches to infectious diseases should not be permitted to overshadow the importance of improving our understanding of the nature of the physiopathologic changes brought about by bacterial action in the body. Infection is frequently an important factor in initiating and aggravating the phenomena of shock since several of the mechanisms concerned in the distribution of an

adequate amount of oxygen in the blood can be specifically impaired by bacteria induced lesions. Bacteria may elaborate capillary poisons, and a variety of lytic enzymes, some attacking cell membranes, and others provoking disturbance in the enzymatic equilibria concerned in the transformation of fibrinogen to fibrin, or to its degradation products. Evidence is cited that these physiopathologic lesions may play an important role in peritonitis and in gas gangrene. The treatment of severe infection should be rationally directed not only toward "parasite extermination," but also toward the prevention and correction of the physiologic derangements which accompany infection. Since this is a relatively new field of effort, it offers many unique opportunities for productive research.

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PHYSIOLOGICAL PRINCIPLES IN INTESTINAL OBSTRUCTION

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RATIONAL therapeutic procedure in the treatment of obstructive lesions of the small bowel is based upon a knowledge of the disturbed physiology which the obstructive condition creates. The therapeutic objective in the treatment of such obstructive cases is twofold: to eliminate the cause of the obstruction and to correct the disturbed physiological processes incident to the obstruction.

To accomplish an adequate restoration of physiological function toward the normal state, a comprehensive knowledge of the fundamental causes underlying the derangement is essential. It is the purpose of the subsequent discussion to present certain common features concerned in obstructive cases which are intimately related to rational treatment.

Intestinal obstruction has been elsewhere defined¹ as a condition in which there exists a cessation, partial or complete, of the normal forward motion of the intestinal content from whatever cause for a period long enough to produce general and local pathological changes. The number and variety of specific causal agents capable of producing such a stasis of bowel content is great, but the actual physiological or pathological mechanisms by which stasis of bowel content or obstruction is caused are few.

In general, it may be said that obstruction is produced in any one or a combination of three ways: (1) occlusion of the intestinal lumen, (2) diminution of peristalsis, or (3) interference or embarrassment of intestinal blood supply. It is also true that these factors are all to a more or less degree interrelated, so that when one of them obtains as an original cause, the others are likely to succeed as secondary effects.¹ It is also true that, when they partially exist in combination, their net effect is just as marked as in a condition in which one of them is operating to a greater degree alone. In other words, obstruction may occur as a result of the partial operation of any one factor or combinations of any of the three factors.

INTESTINAL DISTENTION

However the obstruction is produced, there is one feature that is the inevitable consequence of intestinal stasis. This is the phenomenon of intestinal distention. Once stasis has supervened, distention is cer-

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tain to follow if stasis proceeds unrelieved. The process by which distention occurs can be readily understood when the following facts are reviewed. Where obstructive stasis of bowel content occurs there begins a progressive accumulation of gas and fluid in the obstructed portion of the bowel. The gas content arises from three sources: (1) swallowed air ingested during the process of ordinary deglutition and which constitutes the greatest percentage of the gas accumulation (68 per cent); (2) gaseous interchange with blood circulating to and through the bowel wall (20 per cent); and (3) gas evolved from the action of intestinal bacteria upon the bowel content itself (12 per cent). The gaseous content of the bowel is therefore the total from these sources and its accumulation at and above the point of obstruction is progressive.

The fluid content which also constitutes a part of the distending content is largely derived from three sources: (1) fluid ingested orally and carried to the obstruction site; (2) digestive ferments normally secreted by the digestive glands; and (3) fluid fractions from the blood secreted into the bowel lumen. The relative percentage of these fluid fractions are extremely variable as can be readily understood. The greatest source of fluid within the bowel in obstruction may come from the circulating blood and this is seen predominantly in the case of strangulation.

There is no question that distention provides a powerful stimulus to fluid transudation from the circulating blood into the bowel, and there is little question that the amount of transudation which occurs is roughly proportionate to the degree of the distention. This is a particularly significant feature in the pathological physiology concerned in obstruction and warrants careful consideration since it is intimately related to the state of dehydration that occurs with obstruction.

The mechanism of distention may be summarized briefly as follows. When obstruction supervenes from whatever cause the bowel content becomes more or less static. Gas and fluid are progressively accumulated in the obstructed segment and involve progressively more of the segments of the bowel above the obstructed site. The bowel becomes increasingly more distended and the intraluminal pressure increases. Under the stimulus of increased intraluminal pressure fluid elements of the blood (water and chloride together with other plasma constituents) largely are transuded into the bowel lumen and are therefore lost from the circulating blood volume. The blood volume begins to show the effects of this fluid and salt loss by an elevation of the hemoglobin, red cell count and nitrogenous content, and by a chloride depletion. Since the blood volume must be maintained, fluid enters the circulation from the interstitial spaces to replace that lost into the bowel, with the result that the tissue spaces are depleted. The loss of the chloride fraction into the bowel is at least for a time compensated for by the retention of bicarbonate to maintain the requisite acid base

balance. As the process continues, however, insufficient bicarbonate can be retained to fully compensate for the chloride loss, and the discrepancy between the acid and basic ions must be corrected in some other way. This is brought about by the excretion of the excess basic radical, sodium, by the kidneys. Sodium, however, is the principal factor responsible for retention of water in the tissues. When it is lost through the kidneys, a proportionate quantity of water must be excreted with it and the further dehydration of the tissues ensues. Naturally, if the process continues, the interstitial fluid reservoir becomes exhausted and the water contained in the cells of the tissues themselves stand in danger of depletion to maintain the depleted blood volume. The intracellular water, however, must remain very constant and only slight variations can occur without causing death of the tissues of which the cells are a part. This stage of dehydration is therefore extremely dangerous, and if the process continues, death must invariably result.

The part played by distention which has just been described may be briefly summarized thus:

- (1) Obstruction from whatever cause
- (2) Stasis of intestinal content
- (3) Progressive distention from fluid and gas
- (4) Transudation of fluid and chloride into the bowel from the blood
- (5) $\left\{ \begin{array}{l} \text{CO}_2 \text{ retention} \rightarrow \text{Sodium excretion with water} \\ \text{Water influx to blood from interstitial spaces} \end{array} \right.$
- (6) Loss of intracellular water from the cells themselves
- (7) Death

OTHER EFFECTS OF OBSTRUCTION

While the dehydration effect is perhaps the most important of those produced by distention, the distention factor is basically concerned with other phenomena of considerable consequence in obstruction. Of these, *pain* is one of considerable interest. The pain element incident to distention of the bowel merits close consideration. Pain to a more or less degree is practically always present in instances of obstruction and in the majority of cases is quite characteristic. Almost the only stimulus capable of producing pain sensation within the bowel is distention. Under normal or unobstructed conditions of peristaltic function, intraluminal pressure within the bowel does not rise to a sufficient extent to bring any sensation whatever into conscious levels. However, if the intraluminal pressure is brought above a threshold level, sensations of pain and discomfort are produced. The pain encountered in intestinal obstruction is therefore largely produced by an alteration in the normal intraluminal pressure, and with other factors being equal, roughly proportional to that increase. It will also be recalled that distention serves as a stimulus to peristalsis. When the bowel is put on an abnormal degree of stretch the smooth muscle of its walls responds characteristically by contraction, which is

then followed by a period of relaxation. In general, also, it will be realized that if the intraluminal tension is suddenly increased the contractile response is ultimately greater than if the same tension were gradually applied. By adaptation of these characteristics (largely of smooth muscle of the bowel wall), certain features concerned with the pain phenomenon in obstruction are more readily understood.

In obstruction there is first a stasis of bowel content from the progressive accumulation of fluid and gas within the bowel lumen both at and above the site of obstruction. This stasis produces distention of the bowel wall and increases the intraluminal pressure. A sensation of pain is produced by stretching of the wall. The stretching of the wall also serves as a stimulus to contraction of the smooth muscle within it and its contraction further increases the intraluminal pressure. The pain sensation is thereby augmented with the contracture of the bowel.

The pain of obstruction is therefore usually episodic in nature, increasing at intervals with each wave of peristalsis when the intraluminal pressure is raised and abating with the succeeding period of bowel relaxation. Nor is distention alone the only stimulus which serves to produce or increase the pain sensation. If the effective circulation to the bowel has been reduced through interference with the blood supply, the resultant tissue anoxia causes violent contractions of the viable smooth muscle of the bowel with a proportionate increase in the intraluminal pressure and therefore of the pain itself. It has already been stated that the character and severity of the pain in obstruction is considerably influenced by the rapidity of onset.

Pain produced by distention of the bowel wall is characteristically pain of the visceral type. It is mediated over splanchnic or visceral afferent fibers and as such is poorly localized. Its localization depends upon the height of the obstruction. If the obstruction and therefore the distending stimulus is in the upper or proximal reaches of the bowel, the pain will be diffusely referred or localized to the upper part of the abdomen. Distention in the distal portions of the bowel produces a pain referred lower in the abdomen.

OTHER REFLEX EFFECTS OF DISTENTION

In addition to the obvious dehydration effects of distention there are also other physiological factors concerned with the distention stimulus the exact nature of which remains obscure. It is known that excessive distention of the small bowel suddenly induced is capable of producing in otherwise normal animals marked variations in the respiration and blood pressure even under conditions of profound anesthesia.⁴ These changes have been shown to obtain for as long as the distention persists. These stimuli arising from the excessively stretched bowel will pass over the splanchnic afferents to the central nervous system and thereafter to autonomic and cerebrospinal effer

ents Although there is insufficient experimental or clinical evidence as yet to support any such contention strongly, it does not seem wholly unreasonable to suppose that the shocklike syndrome frequently encountered in certain instances of strangulated obstruction of sudden onset (volvulus for example) may be initiated at least in part on a reflex basis It is well known to those who have frequently to deal with a variety of obstruction cases that in those instances of obstruction in which the mesentery is involved by twisting or compression, shocklike phenomena are very prone to appear, and if the mesenteric embarrassment is corrected, these are promptly relieved

RELATION OF OBSTRUCTIVE VOMITING TO DISTENTION

Obstructive vomiting is intimately related to intestinal distention The mechanism by which such vomiting is produced may be traced to two principal factors, (1) reflex and (2) mechanical, both of which are intimately related to distention

When the bowel wall becomes distended and the intraluminal pressure thereby increased, receptors in the bowel wall are stimulated and these stimuli are transmitted centrally by splanchnic afferent fibers The so called vomiting center in the medulla is stimulated and impulses are sent out over the various afferent tracts, both autonomic (vagus) and cerebrospinal, so that the process of vomiting occurs⁵ Such vomiting is recurrent and tends to persist as long as the reflex stimulus of abnormal distention is present This reflex process concerned in vomiting is well recognized, but there is in addition a mechanical feature concerned in the vomiting of obstruction which is more obscure

It is frequently and erroneously stated that the vomiting in obstruction is produced by a reversal of the peristaltic process Actually, reverse peristalsis rarely, if ever, occurs Peristalsis when present proceeds in one direction only, namely, from the proximal toward the distal portion of the bowel Normally the effective peristaltic component is a segmental contraction of the bowel which constricts the lumen at one point forcing the luminal content into the relaxed portion of the bowel distal to the point of contraction The contracted portion then slowly relaxes and the wave of contraction proceeds to the previously relaxed distal portion into which the lumen content has been forced when the process is repeated The content of the lumen is thus propelled proximodistally under normal circumstances by a series of continuous interrelated undulant waves of coordinated contraction and relaxation of the smooth muscle of the bowel wall⁶ Although peristaltic action is considerably modified by the influence of autonomic innervation of the intestine (vagus-producing stimulation and sympathetic inhibition), it is capable of proceeding independently by its own intrinsic innervation Under conditions of mechanical obstruction, when distention supervenes propulsive peristalsis is altered

in frequency and force but retains its essential characteristics. Under the stimulus of distention the peristaltic waves are increased in frequency and force of contraction to force the bowel content forward past the obstructing point. This increased peristaltic activity may actually be successful in passing the intestinal content by the obstruction point if the lesion producing the obstruction does not completely occlude the bowel. If the obstruction is complete, or nearly so, the forward current of the bowel content is impeded and unable to proceed and there is then set up a reversal of the current of the bowel content which is in the opposite direction to that of the propelling

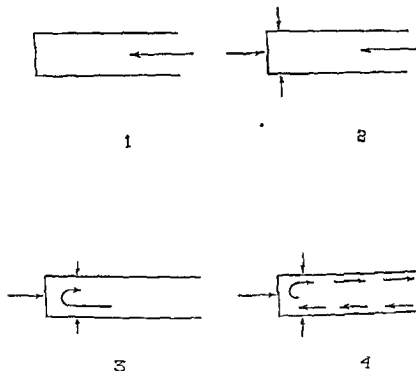


Fig 531 —(For explanation, see text)

peristaltic force. This reflux of the intestinal content is the result, therefore, of several factors.

An analogous condition may be visualized in which there is a distensible tube containing fluid and air which has been sealed at one end. A mechanical force is applied to the walls of the tube, forcing the contained air and fluid toward the sealed end. The gas content can, to a certain extent, be compressed but the fluid cannot. Since the tube is distensible and therefore resilient, its walls distend to accommodate the relative increase in volume of the fluid and air as these are forced with progressively narrower confines toward the sealed end of the tube. But as the tube distends to accommodate its

content, the wall, because it is resilient, also exerts a lateral force on the fluid and air. There are, therefore, three forces acting, namely, (1) the force propelling the tube content forward, (2) a force exerted by the resilient walls upon the tube content at right angles to the propelling force, and (3) the passively acting force of the sealed end of the tube acting in the opposite direction to the propelling force. The motion of the tube content will therefore be determined by the relative amounts of these forces, as illustrated in Figure 531. The tube content is forced against the sealed end of the tube beyond which it cannot progress. Since the force at the sealed end is exactly equal to the propulsive force, the resilient walls of the tube expand, but there is a limit to its resiliency. Though the gas content of the tube can be compressed, the fluid cannot. The result is the tube content must move along the line of least resistance, which, since one end of the tube is open, will be in that direction. In other words, the tube content must move in the direction from which the propelling force is acting. The result is the establishment of a current in the tube content passing first in the same direction as the propelling force to the sealed end of the tube, and then in the opposite direction to the propelling force. This reflux current, once established, tends to be perpetuated by inertia as well as by the forces acting to produce it.

There can be little doubt that a very similar process occurs in mechanical obstruction of the small bowel to account for the persistent vomiting. The bowel is obstructed at some point by a mechanical occlusion of its lumen. Stasis and distention occur. Propulsive peristalsis is stimulated and forces the bowel content against the resisting obstructed site. The resiliency of the intestinal wall for a time accommodates the bulk of progressively increasing intestinal content, but ultimately begins to exert a greater compressing force upon it. Two forces are set up against the bowel content in addition to the forward propulsive force. The unobstructed segment of the bowel being the line of least resistance, a reflux current is set up toward it, and the bowel content passes upward into the next proximal segment. To explain the further passage of the bowel content upward, several additional features must be reviewed. It will be recalled that the contraction-relaxation wave of peristalsis is segmental in action. That is to say, the whole bowel is not involved in peristaltic action at the same time, but only certain of its segments. Moreover, when peristalsis occurs in a segment, *not all of the intestinal content is removed from that segment by peristaltic action*. There remains a residuum of intestinal content in the segment after a wave of peristalsis has passed.

This residuum of bowel content is gradually emptied from the segment by subsequent segmental waves, provided that no increment is added from the reaches of the bowel above. The emptying of any particular bowel segment of its content is therefore a gradual process, proceeding a little at a time with each propulsive peristaltic wave.

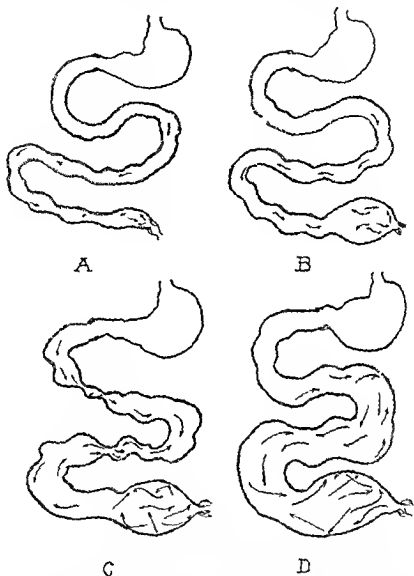


Fig. 532—Diagram illustrating flow of intestinal content above a point of obstruction A, Change in direction of forces immediately after obstruction B, Beginning dilation due to increased pressure in loop C, Extension of dilation of gut to higher levels with contractions insufficient to constrict lumen of gut causing intestinal content to be forced equally in both directions In D, marked dilation of a large segment of gut has occurred and the gut content is forced upward by elastic recoil as well as by contraction of the distended gut in the segments which are not stretched beyond the limit of contractility

A single wave of peristalsis is not an efficient mechanism in emptying the bowel segment in which it is active, since even under normal conditions it requires several, or many, peristaltic waves to do so (To be

teleologically viewed however, it is extremely effective regardless of its efficiency for forward propulsion for it accomplishes the primary purpose of bringing the bowel content in prolonged and wide contact with the largest possible absorptive surface of the bowel mucosa)

When a condition of obstruction is present and the reflux current which has been previously described has been set up, the bowel content is regurgitated retroperistaltically toward the next proximal segment. There is then an increased pressure gradient produced by the retroperistaltically propelled intestinal content from the obstructed segment against which the propulsive peristalsis in the next proximal segment must operate. It has already been stated that even under normal conditions peristalsis is not mechanically an efficient process in emptying the particular segment in which it is active, and against the increased pressure gradient of retroperistaltically propelled content from an obstructed segment, it is even less so. The result is that the bowel content in the next proximal segment is not emptied as much as normally and the residuum after each peristaltic contraction is greater in amount. This increase in content in the segment proximal to the obstructed segment produces distention in that segment. Under the stimulus of distention more fluid is transuded into the proximal segment further increasing the bowel content therein. The result is that the process extant in an obstructed segment is repeated in the next proximal segment namely distention and increase in the bowel content with less emptying of the contained fluid and gas with each peristaltic contraction and thereby stasis and an increased pressure resistance against propulsive peristalsis proceeding toward this segment. This process once initiated and unrelieved progresses with varying degrees of rapidity to involve more and more segments of the bowel above the obstructed segment until the entire extent of the bowel above the obstruction may be involved producing as an end result a greatly dilated portion of bowel filled with fluid and gas in which peristalsis is weak or entirely absent.

PHYSIOLOGICAL PRINCIPLES IN TREATMENT

An understanding of the normal physiology of the gastrointestinal tract as well as the variations from normal encountered in obstruction of the bowel has a direct bearing on therapy. Obviously in cases of obstruction in which distention is not great, and the serious sequelae of distention are not present early removal of the obstruction by operative measures is indicated except for early postoperative cases or cases of patent inactive ileus (so called adynamic ileus). Excluding these latter two groups of cases the great majority when first seen or recognized are not easily amenable to immediate operation and it will be necessary to use some means to restore as nearly as possible the normal physiological status of the bowel. Since distention initiates other harmful responses it is important to control distention as quickly

as possible. Enterostomy is a direct approach for decompression but the obvious difficulties of an operative procedure in a sick patient is sufficient reason to seek other means of decompression.

Intestinal Intubation.—Suction drainage of the stomach or duodenum as popularized by Wangensteen⁷ proves effective in many cases. Vomiting can be controlled by this means. The tension on the bowel above the obstruction is lessened as the reflux of bowel content

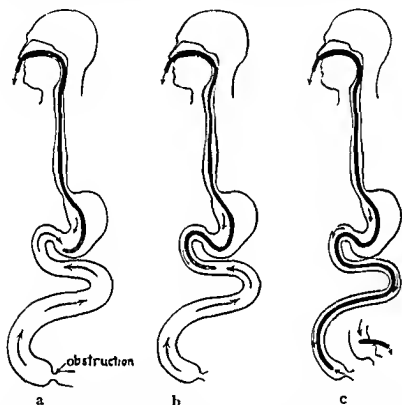


Fig 533—Illustration of differences in direction of flow in intubation at various levels and by enterostomy *a*, Gastric drainage, *b*, duodenal drainage, *c*, small intestinal drainage.¹⁰

is removed and does not tend to return towards the more distended loops of bowel lower down.

The nearer aspiration is applied to the point of obstruction the more efficient is the removal of the distending content. With the use of the Miller-Abbott⁸ tube which can be made to reach any portion of the small bowel without too much trouble, material can be removed effectively from just above the point of obstruction thereby relieving the distention and restoring the normal function of the small bowel.

It is obvious from the foregoing statements that the most important single feature concerned in the treatment of obstructive cases is the

adequate decompression of the distention incident to the obstruction. The role of long tube intubation in intestinal decompression has in general been thoroughly emphasized in previous and current literature.^{9 10 11 12 13} There are, however, certain points concerned in the employment of intubation which will bear constant reiteration, for negligence in their performance may materially impair its results. Technically, successful intubation depends upon accomplishment of the following (1) passage of the tube into the small bowel, (2) maintenance of the patency of the tube, and (3) maintenance of adequate and continuous suction.

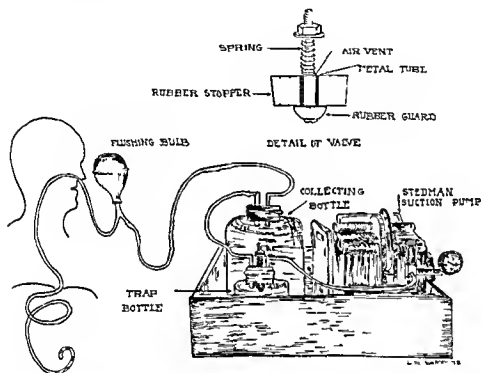


Fig 534—Suction apparatus employed in treatment of intestinal obstruction

The technic of passing the tube into the upper reaches of the small intestine has been adequately stressed in the literature dealing with the subject and needs little additional stress. We have found that once the tube is in the stomach it is a simple matter to pass the tube to the pylorus by turning the patient on the right side, inflating the stomach, and allowing the tip of the tube to drop by its own weight to the pylorus. From this point on, gentle manipulation under fluoroscopic control suffices to pass the tube well into the duodenum where peristalsis, acting on the slightly inflated balloon, carries the tube downward. The use of a fine wire stilet, as recommended by Abbott,¹⁴ is a worthwhile aid in manipulating the tube into the duodenum.

Several types of tube are available. The double lumen tube, while easy to introduce, has such a narrow lumen that it clogs easily and

aspiration is not so good as it is when a larger tube is used. We have found that tubes prepared from Rehfuß type tubing with a smaller tube attached for inflating the balloon is preferable. Tubes with weighted tips, either heavy metal or a leader prepared with a bag of mercury,¹³ are more likely to enter the small bowel without manipulation, but progress more slowly than a tube with an air filled balloon attached.

A tube which lies in the intestine and which does not aspirate intestinal content offers no advantage. Much difficulty is encountered with suction. Too strong suction will collapse the tubing; too weak suction will not aspirate fluid. While the simplest suction apparatus is

We have found that a good constant source of suction is produced by a Stedman or a water pump. The pressure developed thus, however, is too great. Accordingly we have introduced into the trap bottle a simple valve which regulates the pressure to an equivalent of that supplied by a column of water of about three feet (Fig. 534).

Fluid and salt replacement is important. With suction drainage applied just above the point of obstruction, it is possible to maintain adequate fluid and nutritional balance by oral intake. In the early stages of intubation it is necessary to supply fluids and food by vein, not only for replacement of materials lost by suction drainage but to compensate for the dehydration and depletion of body stores present before treatment is begun. Determination of intake and output and observation of the amount of urine excreted and the condition of the skin and mucous membrane offer the best means of determining replacement needs. There are no good formulas for determining the amount of fluid, salt or nutrition which are required.

This discussion relates to cases of simple obstruction. Intubation in cases of strangulation obstruction may keep the gut above the obstruction decompressed, but will not affect the changes in the bowel incident to lack of blood supply, except that possibly the reduction of intraluminal pressure may delay the possibility of perforation.

The use of intestinal intubation in intestinal obstruction is possible because of the physiological response of the intestine to material within its lumen. When normal intestine is distended aspiration of its content restores normal physiological function to the bowel, and allows time for the patient's fluid and salt balance to be restored under relatively normal conditions. Intubation ought not to be considered a form of treatment for intestinal obstruction despite the fact that it is frequently all that is required in many cases. It is but the application of sound physiological principles for the restoration of normal function in the small bowel the functions of which have been markedly disturbed by distention.

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CERTAIN PHYSIOLOGICAL PROBLEMS PERTAINING TO THORACIC SURGERY

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THE advances in thoracic surgery in recent years have occurred largely because of a better understanding of the physiology of respiration and circulation. As the surgeon and anesthetist have become familiar with the physiological problems involved in opening the thorax and with the effects of anesthesia upon respiration it has become possible to open the chest with approximately the same impunity as opening the abdomen.

THE PHYSIOLOGY OF THE OPEN THORAX

Air flows from the point of highest pressure to the point of lowest pressure. Normally when the chest expands the thoracic cage pulls away from the elastic lung and creates a subatmospheric intrathoracic pressure. Room air at atmospheric pressure rushes into the trachea and alveoli until the pressures are equalized or until expiration begins. When the thorax is opened widely either accidentally or surgically air rushes into the thorax through this opening as the chest wall expands quickly equalizing the negative pressure initiated by the expansion of the chest wall. For this reason very little air will be pulled into the lungs through the trachea. Likewise as the chest wall contracts during expiration and air is forced out of this large hole in the chest wall very little air is forced out of the lungs through the much smaller opening of the trachea. Under these circumstances the patient's pulmonary ventilation is markedly reduced. A pressure greater than atmospheric pressure must be applied through the trachea so that proper pulmonary ventilation may be accomplished. This is most easily done by rhythmic squeezing of a reservoir bag filled with air or the anesthetic mixture connected to an endotracheal tube. In this manner the anesthetist can employ positive pressure respiration for hours if need be until the thorax is closed and normal breathing is reestablished. If the pressure exerted by the bag upon the alveoli is higher than the pulmonary capillary pressure it will compress the pulmonary capillaries and for a limited time interrupt the blood flow through the lungs. Consequently the pressure used should not be continuous or excessive. The upper safe limit of positive pressure

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is not definitely known. The normal lungs of dogs do not rupture until 80 to 110 cm. water pressure is applied to the air passages, but it is possible that diseased lungs may rupture at lower pressures. A pressure above the pulmonary capillary pressure probably can be employed for very short periods in attempts to re-expand previously compressed lungs. For routine purposes, the pressure should not exceed 15 cm. of water.

When the thorax is opened the lung on the affected side tends to collapse as air rushes into the pleural space. In addition, the mediastinum tends to deviate to the normal side during inspiration since the air intake through the opening in the chest wall is much larger than that through the trachea. Therefore the lung on the normal side does not expand adequately. The amount of shift of the mediastinum will vary with the position of the patient on the operating table. If the patient is lying with the operated side uppermost, the weight of the heart and mediastinum will compress the good lung, requiring the anesthetist to use more positive pressure in order to maintain adequate ventilation of that lung. If the patient is supine or prone, the mediastinum tends to remain in the midline. Under such circumstances the positive pressure required may be minimal. In fact open thoracic operations may be done with relative safety under local or spinal anesthesia with little or no positive pressure in these positions. If necessary the surgeon may grasp the hilar structures and pull the mediastinum toward the operated side, thereby assisting expansion of the opposite lung. In recent years, Overholt¹ has performed major thoracic operations under local anesthesia and has placed the patient on the operating table with the diseased side slightly in the dependent position by means of a special attachment to the operating table. Although he has done this primarily to prevent spill-over of sputum into the unaffected lung, the weight of the mediastinum helps keep it toward the dependent side and is an aid in the ventilation of the remaining lung.

It is our belief that the use of an endotracheal tube to insure adequate aeration and adequate aspiration of secretions is desirable regardless of the type of anesthesia used. On the other hand, an endotracheal tube is avoided when possible in infants since occasionally laryngeal edema results which may require tracheotomy.

CONTROLLED RESPIRATION

The motion of the chest wall and diaphragm may at times add to the difficulty of the operation. Upon such occasions, the anesthetist can stop the patient's spontaneous respiratory movements and employ controlled respiration. There are three mechanisms by which this may be achieved.

1 *Anesthetic agents which produce marked depression of the medullary respiratory center*—Some anesthetic agents depress respiration, while others leave respiration unchanged or increase it. Cyclopropane

depresses respiratory function moderately in concentrations which produce light surgical anesthesia and leads to complete suppression of respiration in deep anesthesia. Pentothal and morphine also decrease respiratory minute volume. On the other hand nitrous oxide, ether, chloroform and vinethene may stimulate respiration.

The explanation of these differences appears to be as follows. Driggs and Dumke² have shown that all anesthetic agents depress the medullary respiratory centers so far as their response to carbon dioxide is concerned. While doing so, ether, chloroform and vinethene stimulate the respiratory center through vagal reflexes, activated by irritation of nerve endings in bronchioles and alveoli. Nitrous oxide anesthesia may stimulate breathing through carotid and aortic body reflexes as the result of the anoxemia associated with its improper administration. Since cyclopropane, morphine and pentothal being nonirritant do not activate these particular vagal reflexes, respiration is depressed. When anoxemia supervenes as a result of respiratory depression, the chemical receptor reflexes of the carotid and aortic bodies may be aroused to prevent further depression of respiration. Since the carotid and aortic body reflexes are not depressed by deep anesthesia they continue to function and serve to protect the patient against what might otherwise be a dangerous anoxemia. Cyclopropane is usually administered with a high concentration of oxygen so that reflexes initiated by anoxemia do not come into play. Consequently spontaneous respiration stops, and the anesthetist can employ controlled respiration. Cyclopropane is the anesthesia of choice when attempting to employ controlled respiration by depressing the respiratory center. Pentothal and morphine if administered in large dosage with oxygen would produce comparable respiratory depression but intravenous anesthesia is never so controllable as inhalation anesthesia.

2 *Hyperventilation*—If a normal unanesthetized individual hyperventilates vigorously with oxygen for 30 to 60 seconds he has no desire to breathe again for the next 3 to 10 minutes due to the fact that he has lowered his arterial carbon dioxide, raised his arterial oxygen tension and so has removed temporarily the normal stimuli to respiration. When the arterial carbon dioxide tension is reduced sufficiently, even strong vagal or carotid and aortic body reflexes cannot activate the respiratory center. Hyperventilation, performed manually by the anesthetist in compressing the rebreathing bag is even more effective in stopping respiration during anesthesia because all anesthetics depress the respiratory center in its response to carbon dioxide, and carbon dioxide must be rebuilt to a higher than normal level before respiration is resumed. The use of hyperventilation in combination with such respiratory depressants as morphine and cyclopropane is particularly effective.

3 *Curarizing agents*—Curare and Erythrina preparations block specifically the neuromyal junction and so produce paralysis of all skeletal

muscles, including the respiratory muscles. Fortunately the latter are depressed last. Stephens, Harroun and Beckett³ using curare in thoracic surgical operations feel that it allows them to maintain controlled respiration in a much lighter plane of anesthesia than otherwise.

It should be remembered that curare in large doses has actions other than the muscle paralyzing effect. It apparently releases histamine from depots in the body and may produce many of the effects of histamine such as a triple response with red center, flare and wheal (upon intracutaneous injection⁴) bronchospasm⁵ and hypotension⁶. The bronchospasm can be so severe that it may persist despite positive pressure on the anesthesia bag and cyanosis will result. Erythroidine does not produce histamine-like effects and might be used to replace curare.⁴ Neostigmine is a physiological antidote to the paralyzing effect of erythroidine and curare and will promptly initiate respiration previously arrested by these drugs. It will not neutralize the histamine-like action of curare.

THE RECOGNITION OF PULMONARY INSUFFICIENCY—OXYGEN THERAPY

Cyanosis and dyspnea are considered to be valuable signs of pulmonary insufficiency. However, it is important that the surgeon recognize the limitations of these signs in the patient with thoracic disease.

Cyanosis is not always reliable as a sign of pulmonary insufficiency for several reasons. (1) Cyanosis is merely a visual appreciation of blueness of the capillary blood which is overlaid by mucous membrane, skin or fingernail. Comroe and Botelho⁷ found that, in white subjects with normal amounts of hemoglobin, experienced observers were usually unable to be certain of cyanosis until the arterial oxygen saturation had fallen to 76 to 85 per cent. In the pigmented races cyanosis is even more difficult to detect. (2) Cyanosis may be purely a local phenomenon and not representative of the degree of systemic anoxemia. Cold, for example, leads to a constriction of peripheral vessels, blood then flows so slowly through the cold extremities that most of the oxygen is extracted from each unit of blood. Hence the skin is cyanotic though the arterial blood may be perfectly normal in respect to its oxygen content. (3) The patient's color is affected by the amount of circulating hemoglobin. If the patient's hemoglobin is very low he may be suffering from severe hypoxia and yet not be noticeably cyanotic since the presence of a certain amount of reduced hemoglobin (5 gm per 100 cc) is considered necessary for the visual appreciation of blueness. (4) An individual may be markedly anoxic and yet not be cyanotic. In both carbon monoxide and cyanide poisoning despite intense tissue anoxia, the blood is bright red. Carbon monoxide combines with hemoglobin to form a pigment which is bright red but will not carry oxygen. Cyanide prevents the tissues

from utilizing the oxygen in the blood stream so that the venous blood remains arterial in respect to its oxygen tension.

Dyspnea is another almost invariable accompaniment of pulmonary insufficiency. However, it must be remembered that *dyspnea* can occur in conditions in which the lungs are normal. *Dyspnea* may occur in diabetic or uremic acidosis, in high fever, and in shock or hemorrhage as well as during severe anoxia or carbon dioxide retention. On the other hand, anoxemia is not necessarily signaled by *dyspnea*. One individual may show no increase in his respiration while breathing 8 per cent oxygen while another may increase his respirations by 200 per cent. As a rule the oxygen content of inspired air must be reduced to 10 per cent before the respirations are increased by as much as 30 per cent and at this time the arterial oxygen saturation is 70 to 80 per cent instead of the usual 95 to 98 per cent.⁸ Of course if the lung is unable to eliminate carbon dioxide, hyperpnea and *dyspnea* usually result in an unanesthetized patient.*

The best clinical test for anoxemia is the determination of arterial oxygen saturation. The procedure of arterial puncture involves no unusual discomfort or danger and should be employed more frequently. We usually obtain arterial blood from the femoral artery though the brachial or radial artery may be used.

Oxygen is often used when it is not needed. Frequent errors in oxygen therapy are (a) to supply oxygen to relieve all types of *dyspnea* and (b) to remove oxygen if it does not relieve the *dyspnea*. *Dyspnea* may be caused by a number of factors each of which is capable of increasing respiration. For example, we recently studied a young male adult with staphylococcal pneumonia and septicemia who was markedly cyanotic and *dyspneic*. The oxygen saturation of his arterial blood was only 39 per cent. Inhalation of 100 per cent oxygen increased his arterial oxygen saturation to 90 per cent but his *dyspnea* continued unchanged. This may be explained by the fact that this patient's *dyspnea* was caused by at least six factors of which anoxemia represented only one. The other five were (1) vagal (Hering Breuer) reflexes irritated by pneumonic patches in the lungs, (2) fever of 104° F. which increased respiration by augmenting the metabolic rate of the carotid and aortic bodies and the medullary center, (3) arterial acidosis (pH 7.1) which can cause marked reflex hyperpnea through the chemical receptors, (4) anemia (hemoglobin 50 per cent) which

* Anoxemia increases respiration, pulse and blood pressure by a reflex action upon nerve receptors in the carotid and aortic bodies rather than by a stimulant effect directly upon the medullary centers as formerly believed. Thus a definite function can now be assigned to these bodies, erroneously thought to be chromaffin tissue with no known physiological action. In addition to acting as a defense mechanism of the body against anoxia, the carotid and aortic bodies are also stimulated by blood acidity (as in acidosis) by high blood carbon dioxide and by a number of drugs used in circulation time tests such as sodium cyanide, lobeline and papaverine.*

probably stimulates the medullary respiratory center, and (5) hypotension (80/40 mm of mercury) which can cause increase in respiratory rate reflexly by an action on the pressure receptors in the carotid sinus and aortic arch. It is obvious then that oxygen therapy cannot be expected always to relieve dyspnea and further that the indication for its use can be judged best by the arterial oxygen saturation.

We usually use oxygen therapy after thoracic operations at least until the patient has recovered from the anesthetic, as it offers him a reserve which he might not otherwise have. There are three methods by which oxygen may be applied. The face mask if well fitted delivers the highest concentration of oxygen to the inspired air (90 to 98 per cent oxygen), however, it is often uncomfortable and not tolerated well. It is undesirable for the patient coming out of anesthesia because of the possibility of aspirating vomitus. Oxygen tents as usually employed in hospital practice produce an average oxygen concentration of only about 30 per cent instead of the 50 to 60 per cent concentration claimed by their manufacturers. The tent is also undesirable in that it interferes with the nursing of the patient. A catheter placed in the oropharynx usually permits the inhalation of 40 to 45 per cent oxygen, its chief drawback is that it irritates and tends to dry the pharyngeal mucosa causing the formation of tenacious mucus. However, of the three methods we have found the nasal catheter to be most satisfactory for routine use.

Oxygen should not be used continuously for more than twenty-four hours in concentration higher than 60 per cent because of the danger of irritation of the respiratory tract.¹⁰

FACTORS WHICH MAY REDUCE PULMONARY EFFICIENCY POST-OPERATIVELY

1 **Improper Ventilation of the Lungs—Mediastinal Shift.**—The most important physiological problem in the immediate postoperative care of the thoracic patient is the maintenance of an adequate respiratory exchange. When a pneumonectomy has been performed, the remaining lung must be ventilated satisfactorily. Ventilation can be accomplished most satisfactorily in man by maintaining the mediastinal structures in the midline or only slightly toward the operated side. If too much air is left in the pleural cavity, the mediastinum is shifted away from the operated side, the remaining lung will be compressed and ventilation will be impaired. If too little air is left in the pleural cavity, the mediastinum will be pulled toward the operated side thereby overdistingending the remaining lung. In man the cardio-respiratory mechanism is seriously disturbed by this procedure probably due to the sudden acute emphysema of the remaining lung or by the interference in the return of blood to the heart.¹¹ If the patient

has been operated upon on his side it is best to close the chest with a small catheter in the incision. The patient can then be turned on his back and palpation of the trachea and heart beat will enable one to determine the position of the mediastinum. Enough air can then be withdrawn to bring the mediastinum to the midline and the catheter removed. A more accurate method is to use a pneumothorax apparatus and remove air until the intrathoracic pressure is about 15 cm. of water below atmospheric pressure. The position of the mediastinum should be checked frequently by x ray and air added or withdrawn if the mediastinum is too far from the midline. It has been our experience that if the chest is closed with the mediastinum only slightly toward the operated side no further tapping may be required. As the air is absorbed serum takes its place. Later the serum clots and contracts and pulls the mediastinum over but this gradual shift is well tolerated.

When a lobectomy has been done it is important to maintain a negative pressure in the chest of about 10 cm. of water so that the remaining lobes may expand and fill the pleural cavity. This is most easily done by using a drainage tube leading to a water trap. Air may be expelled from the chest when the patient strains or coughs but cannot be pulled back into it. Upon inspiration water will be aspirated into the tube and a negative pressure will be maintained. As a rule the lung will seal against the pleura and the tube may be removed in four to five days.

In a thoracotomy in which drainage is not used it is important to expand the lung completely as the pleural cavity is closed. This may be done by moderate pressure exerted by the anesthetist on the anesthetic bag connected to the endotracheal tube or by suction in the pleural cavity applied through a catheter which can be removed as the wound is closed.

Phrenic paralysis produced at the time of operation may interfere with proper ventilation of the lungs. It is true that following lobectomy or pneumonectomy paralysis of the phrenic nerve allows the diaphragm to rise and helps fill the space left by the resected lung. Nevertheless following lobectomy normal diaphragmatic motion is helpful in maintaining adequate ventilation of the residual pulmonary tissue during the immediate postoperative period. A paralyzed diaphragm will move paradoxically during respiration thereby decreasing its efficiency. This is true also following pneumonectomy as paralysis of one side of the diaphragm will allow some paradoxical movement of the mediastinum and reduce the efficiency of the efforts at ventilating the remaining lung. Months later with the contraction of the fibrothorax even the nonparalyzed diaphragm assumes a high position but the mediastinum is fixed and pulled over by the same process.

2 Atelectasis—Improper Ventilation of the Lungs Due to Mucus in the Tracheobronchial Tree—During the postoperative period

many thoracic surgical patients have mucopurulent material in the tracheobronchial tree. This is not only true after operations for the relief of suppurative disease but also frequently following simple thoracotomy in patients with chronic tracheobronchitis. It is important that this material be coughed out and not allowed to accumulate. During the immediate postoperative period, a nurse should be at the bedside almost constantly with a suction apparatus to aspirate mucus from the pharynx. If the patient is unable to keep the tracheobronchial tree free of secretion, tracheal aspiration with a catheter should be done at frequent intervals. If this is done diligently a severe atelectasis requiring bronchoscopy will seldom occur.

When massive atelectasis occurs as a result of acute bronchial obstruction the patient becomes cyanotic because blood continues to go through the atelectatic lung thereby delivering unoxygenated blood to the systemic circulation. On the other hand, a patient may develop bronchial obstruction slowly and eventually have an atelectatic lung without having cyanosis. These points may be demonstrated by two recent patients. One developed right bronchial obstruction *slowly* over a two month period at the end of which time the arterial oxygen saturation was 92 per cent. The other had repeated *acute* episodes of obstruction of the left main bronchus during which his arterial oxygen saturation fell to 62 per cent. This is probably due in the first case to the gradual reduction of the blood flow through that lung which accompanied the slowly developing atelectasis, while in the second case the blood flow must have continued during the acute obstruction. A similar situation may occur during pulmonary resection if the bronchus is clamped before the blood supply. However, this is of no clinical importance because the manipulation of the lung probably reduces the blood flow through it. Furthermore, the interval between occluding the bronchus and the blood vessels is usually relatively short.

Atelectasis may be favored by the use of oxygen. If the occluded portion of the lung contains oxygen, collapse will occur much more *rapidly* than if it contains air since oxygen is quickly taken up by the blood flowing through the lung, whereas nitrogen is carried away by the blood very slowly.

3 Postoperative Pain.—Because of pain in the wound, the patient may decrease his respiratory excursion and suppress the coughing which is essential to rid the tracheobronchial tree of mucus. If enough morphine is given to relieve pain the patient's cough reflex may be inhibited to a considerable degree. On the other hand with no pain relief the patient may not be able to cough. It is difficult to administer just enough morphine to give some pain relief and yet not to inhibit the cough reflex. Upon occasion however, we have seen a dose of morphine allow a patient to cough more effectively by relieving the pain usually experienced during coughing following thoracic operations.

Under these circumstances intercostal nerve block with procaine is often useful in relieving the acute distress and allowing the patient to cough effectively. In recent years we have frequently cut or crushed five or six intercostal nerves from within the chest at the time of operations in old people. This gives an anesthetic wound except for the posterior part and is often helpful in allowing the patient to cough freely during the postoperative period.¹

4 Postoperative Pulmonary Edema—In the postoperative patient it is often difficult for the surgeon to differentiate between true pulmonary edema and the production of mucopurulent material incident to irritative phenomena. It is important therefore that the surgeon have an understanding of the physiological mechanisms responsible for the production of pulmonary edema. These factors are those which enter into the formation of peripheral edema, namely capillary pressure, colloidal osmotic pressure of the blood, tissue pressure surrounding these capillaries and permeability of the capillary walls.

In the systemic circulation there is constantly a filtration of fluid outward on the arterial side of the capillary and inward at the venous side of the capillary. This is due to the fact that the colloidal osmotic pressure of blood is η

(25 mm of mercury)

the arterial end of the

mercury (5 mm higher than the colloidal osmotic pressure) so that fluid passes into the tissue spaces. At the venous end the capillary pressure is only 10 to 15 mm of mercury so that fluid is drawn into the circulation by the colloidal osmotic pressure of the plasma protein.

While the colloidal osmotic pressure of the blood remains about the same in various capillaries throughout the body, capillary blood pressure varies greatly in different organs. In pulmonary capillaries the pressure is quite low. While direct measurements of pulmonary capillary pressure have not been made in man, judging from the pulmonary arterial pressure of 20 mm of mercury it is believed that the actual capillary pressure is 5 to 10 mm. Since the colloidal osmotic pressure is the same as in the systemic circulation (25 mm of mercury) it is apparent that at both ends of the pulmonary capillary the force drawing fluid into the pulmonary capillary is greater than the force tending to push fluid out. In this respect the pulmonary circulation differs markedly from the systemic. This arrangement is of great importance in keeping the alveolar surface free of fluid so that oxygen uptake and carbon dioxide elimination can proceed efficiently. This feature was dramatically illustrated in 1875 by Colin who poured 21 liters of water into a horse's trachea.

period this produced no ill effects

absorbed from the alveoli because of

colloidal osmotic pressure relationship that is unique in the lungs

FACTORS TENDING TO PRODUCE PULMONARY EDEMA—The abnormal

conditions which may interfere with these pressure relationships and allow the formation of pulmonary edema are as follows

(a) *A Marked Rise in Capillary Pressure*—The pulmonary capillaries are capable of great dilation and up to a certain point they can accommodate a great deal of blood without an appreciable rise in capillary pressure. When this limit has been exceeded, the capillary pressure may rise abruptly to exceed the colloidal osmotic pressure and pulmonary edema will form. This limit is difficult to exceed in normal individuals. The Blalock operation for pulmonary stenosis suddenly shunts blood from the high pressure systemic circulation into the low pressure pulmonary circulation. The pulmonary capillaries are able to dilate and absorb this pressure without the production of pulmonary edema.

However, when the pulmonary circulatory reserve is exceeded pulmonary edema occurs. This occurs in congestive heart failure when the blood volume is increased and the pulmonary capillaries are engorged. In patients with marked decreases in pulmonary circulatory capacity, pulmonary edema may occur with increases in blood volume which a normal lung could tolerate. Gibbon¹³ demonstrated that cats following multiple lobectomy developed pulmonary edema and died if transfused with a volume of blood that was well tolerated by cats with normal lung capacity. With a reduction in the size of the pulmonary capillary bed the increase in blood volume probably increases the pulmonary capillary blood pressure and pulmonary edema results. During a pneumonectomy it is possible that blood loss may be overestimated and the patient's blood volume increased so much by transfusion that pulmonary edema may occur. Certainly it is important in such cases to look for evidence of increased venous pressure and to withhold further transfusion when such signs are present.

(b) *The Production of a Marked Negative Intrathoracic Pressure*—As long as the tracheobronchial tree is open subatmospheric pressure in the thorax created by expansion of the chest wall is quickly equalized by the rush of air into the lungs through the trachea. If there were a partial inspiratory obstruction to the tracheobronchial tree the intrathoracic pressure might become so markedly subatmospheric that a suction or cupping effect would be present which would withdraw fluid from the capillaries and lead to pulmonary edema. This condition occurs rarely.^{14 15}

(c) *A Reduction of Colloidal Osmotic Pressure of the Blood*—If the colloidal osmotic pressure were suddenly reduced the capillary pressure might exceed it and thereby produce pulmonary edema. This may play a part in the production of pulmonary edema incident to the excessive administration of intravenous glucose or saline. The rise in the capillary pressure is the result of the sudden rise in blood volume. It is probably the major factor however. For example, Altschule¹⁶ found that 1800 cc. of 0.9 per cent sodium chloride could be given

intravenously in 40 to 185 minutes to normal adults with no signs of pulmonary edema, while 1000 cc given in 50 minutes made patients with congestive heart failure much worse

(d) *An Increase in Capillary Permeability*—Capillary permeability is increased by prolonged tissue hypoxia as in inadequate ventilation during a thoracic operation by trauma either surgical or accidental by infection as in pneumonia, by ischemia, as in an infarct and by irritating gases such as nitrous fumes and phosgene. Blast injuries produce lung trauma due to the fact that the wave of pressure is transmitted to the thorax before it reaches the alveoli by way of the trachea. If the wave were to hit the lung tissue externally and internally at the same time, the lung itself would not move and therefore would not be traumatized.

TREATMENT OF PULMONARY EDEMA—The treatment of pulmonary edema may logically be discussed by attempting to reverse the four chief factors tending to produce edema.

(a) Pulmonary capillary pressure may be reduced by suddenly reducing blood volume. This is best done by venesection which is often helpful in cardiac failure and might be helpful if pulmonary edema were precipitated by overtransfusion following pneumonectomy.

The pulmonary capillary pressure may also be lowered at times by trapping blood in the peripheral circulation by applying to the thighs blood pressure cuffs inflated to the point of allowing blood to enter but not to leave these extremities.

Any measure which dilates systemic vessels results in the redistribution of blood away from the lungs and toward the systemic circulation. Aminophylline probably acts by dilating systemic vessels and simultaneously stimulating the left ventricle to pump blood more vigorously out of the lungs.

(b) The production of positive pressure within the lungs will oppose the outward filtration pressure produced by the capillary blood pressure. Pressure breathing has been used in the treatment of pulmonary edema of various etiology. We believe that it is of no value in pulmonary edema caused by irritant gases. Sufficient objective evidence has not yet been obtained upon which to evaluate pressure breathing therapy in pulmonary edema due to trauma¹⁷ or to congestive heart failure.¹⁵ Pressure breathing appears to be of definite value only in overcoming the bronchoconstriction of asthma.¹⁸ Its employment in cases of pulmonary edema should be regarded as an investigative problem.

(c) An acute increase of pulmonary blood osmotic pressure probably has no practical usefulness in treating pulmonary edema. If hypertonic plasma were used it would increase the blood osmotic pressure and fluid would be drawn into the circulation. However this would increase the blood volume and consequently the pulmonary capillary blood pressure which in itself would tend to produce pul

monary edema. We have seen a patient with nephrosis given a large dose of acedia with the thought of producing diuresis. The blood volume increased so rapidly that the patient developed severe pulmonary edema. His life was undoubtedly saved by an emergency phlebotomy.

(d) Little can be done to reduce the permeability of the capillary wall injured by trauma, irritating gases or anoxia except removal of those factors which originally injured the capillaries, and administration of oxygen. Administration of 100 per cent oxygen may in itself lead to pulmonary edema if used continuously for twenty four to forty eight hours. When it is necessary to employ oxygen for long periods, it is probably best to use not more than 60 per cent oxygen.

5 Late "Compensatory Emphysema" following Pneumonectomy without Thoracoplasty.—When a total pneumonectomy has been done without drainage and infection does not occur, the pleural cavity gradually becomes filled with serum which clots and retracts to form a fibrothorax. As the retraction takes place over a period of several months, the mediastinum is pulled over and the remaining lung is greatly overdistended. This is not true hypertrophy but a type of emphysema. This "compensatory emphysema" corrects the anatomical defect but in so doing produces a physiological one, since as with all types of emphysema the efficiency of the lung is reduced. Cournand and Berry¹⁹ and Cournand and Lester²⁰ have shown in adults and children that the respiratory reserve following pneumonectomy is greater if a thoracoplasty has been done to prevent the shift of the mediastinum and overdistention of the remaining lung.

It would seem therefore that a thoracoplasty should always be performed following total pneumonectomy. However, one is often reluctant to advise another major operation when the patient has just had a pneumonectomy. When one is dealing with carcinoma and an uncertain life expectancy one is even more hesitant to use up part of that life expectancy with an elective thoracoplasty. On the other hand, the evidence is clear that overdistention of the remaining lung is harmful. We therefore feel that it is wise to advise thoracoplasty following pneumonectomy in nonmalignant disease, especially in young people with long lives ahead of them.

SUMMARY

Certain physiological problems pertaining to thoracic surgery have been reviewed.

- 1 The physiology of the open thorax has been discussed.
- 2 In order to employ controlled respirations, spontaneous respiratory movements may be stopped by anesthetic agents which depress the medullary respiratory center, by overventilation, or by curarizing agents.
- 3 The recognition of acute pulmonary insufficiency is often difficult.

Cyanosis and dyspnea may not be reliable indices. The arterial oxygen saturation is the most reliable simple method of determining the efficiency of the lungs.

4 Factors which may reduce pulmonary efficiency have been discussed. These are (a) improper ventilation of the lungs due to factors outside the lung such as mediastinal shift or paradoxical movement of the diaphragm or mediastinum, (b) mucus in the tracheobronchial tree leading to atelectasis, (c) postoperative pain, (d) postoperative pulmonary edema. The pulmonary efficiency may also be reduced months after pneumonectomy by "compensatory emphysema" if a thoracoplasty has not been done.

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THE PATHOLOGIC PHYSIOLOGY OF HYPERTHYROIDISM

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IN the care of thyroid disease physiological study has often led directly to improvements in therapy and to reduction in mortality. For this reason a consideration of the physiological aspects of the subject inevitably includes a consideration of such important therapeutic advances as the use of iodine, certain of the pre- and postoperative measures which have lowered the surgical mortality, the use of thiouracil and the use of radioactive iodine.

First however, it is well to point out that hyperthyroidism probably may arise by two mechanisms. In *nodular toxic goiter*, one or more areas in the thyroid gland appear to grow and to function more or less independently of the rest of the body. The hormonal material formed in such areas is absorbed into the blood stream and affects the remainder of the body. According to this interpretation nodular toxic goiter acts by much the same mechanism as parathyroid adenoma, island adenoma of the pancreas and other primary tumors of endocrine origin. *Diffuse toxic goiter*, on the other hand, is believed to result from a disturbance in the endocrine system not confined to the thyroid gland.¹ The thyrotropic hormone produced by the anterior pituitary is a necessary agent in bringing about the increased thyroid activity.²

The effects on the body of both forms of hyperthyroidism are so nearly the same that they can properly be discussed together. The differences between the two conditions will be commented upon first. The *exophthalmos*, so characteristic of diffuse toxic goiter, is not characteristic of nodular toxic goiter. After subtotal thyroidectomy for diffuse toxic goiter, exophthalmos occasionally increases and may even go on to corneal ulceration and loss of one or both eyes (malignant exophthalmos). In guinea pigs Marine and Rosen³ have been able to produce exophthalmos by total thyroidectomy and the injection of anterior pituitary extract at regular intervals.⁴ The rationale of this procedure is that loss of thyroid function causes the anterior pituitary to produce excessive amounts of thyrotropic hormone. It is postulated that the exophthalmos is produced as a by-product of the hyperfunction of the anterior pituitary. Exophthalmos does not result from the administration of thyroxine.

The theory leaves certain matters unexplained such as why malig-

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nant exophthalmos is so rare after subtotal thyroidectomy and why in so many instances the exophthalmos slowly recedes over a period of many months following operation. The older view of clinicians was that subtotal thyroidectomy broke a vicious circle and allowed the body to readjust toward normal. Perhaps when more is known about the factors affecting pituitary function, the explanation of these discrepancies will be evident.

Another difference between diffuse toxic goiter and nodular toxic goiter lies in the response to roentgen therapy. The former, in general, responds more satisfactorily than does the latter.

For many years it has been taught that the administration of iodine to a patient with nodular nontoxic goiter leads to the appearance of toxicity. As a high percentage of nodular nontoxic goiters become toxic without iodine medication, it is not easy to prove this impression. As far as we are aware, no satisfactory statistical data exist to support it. The goitrogenic action of iodine has been contested by Ruenhoff.⁵ Nodular toxic goiters, however, respond well to iodine when it is used in preparation for operation, with a reduction in basal metabolism almost as satisfactory as that observed in diffuse toxic goiter.

Cardiac symptoms are more prominent in nodular toxic goiters than in diffuse toxic goiters. This is, no doubt, due at least in part to the higher mean age of patients with the nodular variety. Rose⁶ has recently reviewed this subject and reemphasizes the occurrence of certain cases in which the cardiac symptoms appear to arise before the basal metabolic rate exceeds normal limits.

Except for related compounds that probably represent precursors, thyroxine is the only hormone known to arise in the thyroid gland. It was purified by Kendall,⁷ and the structural formula was determined and the compound prepared synthetically by Harington and Barger.⁸ While there has been considerable speculation regarding the possibility of other hormones, so far none has been demonstrated, and thyroxine reproduces the symptoms of hyperthyroidism fairly well in animals except for the exophthalmos.

The basic function of thyroxine is to increase the metabolism of the individual cell as measured by the oxygen consumption. One milligram of thyroxine increases metabolism by about 1000 calories in a normal adult.² Hyperthyroidism, therefore, puts an added load on what may be termed the transportation systems of the body. Thus the respiratory exchange is increased, the heart rate is increased, usually the systolic pressure is elevated and the pulse pressure is widened. This may produce a capillary pulse which can be seen when a nail bed is partially blanched by pressure. It may produce the Corrigan pulse at the wrist and Traube's pistol shots upon auscultation over the femoral artery at the groin. If the load on the heart is too heavy and continues too long, cardiac decompensation will result. Slight ankle edema and dysp-

nea on mild exertion are common even in patients who do not develop the more severe signs of decompensation. The heart usually enlarges, most of the enlargement being due to left ventricular hypertrophy. The apex impulse is exaggerated and subjectively the patient complains of palpitation. Extrasystoles commonly develop, and auricular fibrillation is not infrequent and may lead to rapid decompensation which is often alleviated with remarkable promptness by digitalization and slowing of the apical rate. The thyroid hormone also acts directly on the heart itself as indicated by acceleration of the rate in preparations of animal hearts *in vitro*.

The cardiac rat by Goetsch⁹ as a diagnosis, and it is considered not to be without danger. Probably related to this fact is the observation that sudden death believed to be due to ventricular fibrillation may occur in hyperthyroid patients if they are anesthetized with cyclopropane. It has been shown¹⁰ that ventricular fibrillation could be induced in animals anesthetized with cyclopropane if epinephrine was administered intravenously.

Epinephrine should, therefore, never be mixed with solutions of local anesthetics used in hyperthyroid patients, and most anesthetists now avoid cyclopropane anesthesia alone in this group of patients. It is considered less dangerous from this viewpoint if ether is added.

One might expect an increase in the hemoglobin such as is observed in chronic cardiac disease, but this seldom occurs. Probably the body is at a disadvantage in the production of hemoglobin due to the demands of the tissues for unusually large quantities of food to meet the accelerated metabolic rate. While at first the appetite is increased and the food consumption of the patient is often a matter of surprise and concern to the patient's relatives, weight loss is the rule and may in severe cases mount to 30 to 40 per cent or more of the body weight. One of the food requirements which is increased by hyperthyroidism is the requirement for thiamine. Unfortunately the American dietary contains a very limited excess of this vitamin estimated to be perhaps only 60 per cent above basal requirements. In hyperthyroidism the basal requirement may be doubled, and signs of thiamine deficiency frequently supervene and distort the disease picture. Thus, anorexia may develop in the later stages of hyperthyroidism. This, of course, completes a vicious circle, and such patients are usually very poor risks when seen by the surgeon. To what extent other relative vitamin deficiencies occur is not fully known. Prothrombin deficiencies occur commonly after thyroidectomy, and Lord and Andrus¹¹ have recommended the administration of vitamin K. It is probable that this change is associated with hepatocellular injury which was demonstrated by Boyce and McFetridge¹² with the hippuric acid conjugation test for liver function.

Diarrhea is common in severe cases and to what extent vitamin deficiencies enter into its etiology is not known

A frequent sign of *protein depletion* is a mild hypoproteinemia Brown and Mecray¹³ observed a difference of 0.82 gm per 100 cc in the plasma protein level of hyperthyroid patients between the samples of plasma obtained preoperatively and the samples obtained three to six months after thyroidectomy While this difference is moderate, it undoubtedly signifies a considerable depletion in the readily available proteins in some of the patients The amount of protein required for nitrogen equilibrium in hyperthyroidism under conditions in which the high caloric requirements of the patient are met by carbohydrate and fat has not been accurately determined Undoubtedly much of the wasting observed clinically is due to the catabolism of body proteins to meet caloric requirements when the intake of food is insufficient for this purpose

The *hepatic damage* in hyperthyroidism may well be due to several factors Undoubtedly the work of the liver in intermediary metabolism is greatly increased as the metabolic requirements of the tissue increase A direct effect of thyroid hormone on the liver cells is another possible factor The progressive loss of body protein and the relative deficiency of certain vitamins appear to be adverse factors Other possible factors are the circulatory changes and the disturbances in the intestinal tract While it is not possible at present to state which factors are the most important, it is clear that the liver tends to become embarrassed in hyperthyroidism From this standpoint, therapy should include the administration of an excess of the known vitamins—particularly the components of the B complex, and a caloric intake in excess of the high requirements indicated by the size of the patient and his basal metabolic rate with a liberal allowance of protein In this clinic approximately 20 per cent of the total number of calories is provided in the form of protein, and most of the remainder is provided in the form of carbohydrate

The *nervous symptoms* of hyperthyroidism are often the most prominent, and while it is easy to imagine how they might arise in individuals who are constantly frustrated by weakness and fatigue, it would serve no useful purpose to enlarge upon such possibilities here Suffice it to say that these manifestations are deeply colored by the personality of the individual and in some cases of severe hyperthyroidism they are almost completely lacking (apathetic goiter) Experience has taught clinicians to be especially wary in assessing the risk of operation in such individuals

A direct effect of the increased metabolic rate of hyperthyroid patients is their *intolerance for hot weather* In order to dissipate the excessive heat produced by their metabolic processes the skin is characteristically warm and moist They tend to perspire excessively if the temperature rises and they are often more tolerant of cool environ-

ments than they were before the disease developed. The body temperature is usually held close to normal unless 'crisis' develops, but mild elevations of 99° to 99.6° F are common in hot weather.

The relation of thyroid activity to the blood iodine level has received considerable attention in recent years. The absolute values are low, 10 to 12 micrograms per 100 cc,¹ but in hyperthyroidism the values average perhaps two to three times this amount. According to Lahey,¹⁴ however, the values are not elevated preoperatively in all cases, and the tendency for thyroid disease to recur is much higher in this group. It is largely confined to those cases in which the level rises postoperatively.

Immediately following thyroidectomy there is a marked rise in the urinary excretion of iodine, but this is a nonspecific effect commonly occurring after other operations.

While the study of blood iodine levels has added much to our knowledge of the physiology of the thyroid gland, it does not appear to be needed for the routine management of clinical hyperthyroidism.

• THYROID CRISIS

Thyroid crisis is a poorly delimited condition characterized by rapid advances in pulse rate and temperature and usually terminating in death. The blood pressure tends to fall and the patient may be restless, excited or delirious. It may occur in the unoperated patient but is seen most frequently after operation, the onset usually coming in the first forty-eight hours. Fatal thyroid crisis is fortunately rare with present day methods of treatment. Some physicians use the term for any severe postoperative temperature rise. Others reserve it for cases in which life definitely appears to be threatened. Obviously there is no sharp line of division but we have preferred to reserve the term for the severe cases and have observed that recovery is the rule if the patient's mental condition remains normal or if the pulse remains below 150. Little is known about the exact changes that occur, but it seems as though metabolism becomes so rapid that the body is unable to dissipate the heat produced with the result that the temperature rises and accelerates tissue metabolism further. The vicious circle thus produced can readily lead to the fatal result and apparently does so in heat stroke. A somewhat similar picture occurs in liver shock, and some investigators have considered the possibility that failure of the already damaged liver may play an important role in fatal cases of thyroid crisis. As in heat stroke and in some cases of liver shock the application of cold in amounts sufficient to reduce the body temperature promptly has been very valuable in incipient cases of thyroid crisis. The rationale of this therapy rests on a sound experimental basis in that elevations in body temperature have been shown to increase basal metabolism approximately 8 per cent per degree.

oxygen therapy is employed continuously to assist the body in preventing tissue anoxia. Glucose is given continuously by vein in order to meet the metabolic requirements of the body. After operation for hyperthyroidism intravenous infusions of 5 or 10 per cent glucose were routinely employed by Frazier in this clinic after 1928. The use of higher concentrations of glucose was recommended by Frazier in 1936.¹⁵

E ACTION OF CERTAIN THERAPEUTIC AGENTS IN HYPERTHYROIDISM

Radiation therapy is believed to injure the endothelial lining of blood vessels leading to the obliteration of some of them with the result that the blood supply of irradiated tissues is reduced. Considerable fibrosis generally results. There may also be a direct effect on the secreting cells in the thyroid. The effect of external roentgen therapy is usually delayed so that one has to wait perhaps four weeks before to observe the maximum reduction in the basal metabolic rate. Recently, however, Hertz and Roberts¹⁶ and Chapman and Evans¹⁷ have taken advantage of the fact that 80 per cent of a small dose of iodine is fixed in the thyroid within a few hours after ingestion provided that the patient has received no iodine medication during the preceding four weeks. The *radiodactive iodine* produced by bombardment of metallic tellurium by means of the cyclotron was given orally and resulted in internal irradiation of the thyroid.

There has been some concern lest the radioactive iodine exert a mutagenic effect in the thyroid, but this had not occurred in the two cases reported.

The action of *ordinary iodine* in hyperthyroid disease has been of the greatest importance and has made the surgical treatment relatively safe. It was originally suggested by the work of Marine and Hart¹⁸ and received wide clinical application by Plummer¹⁹ at the Mayo Clinic.

Administration is followed by a rapid deposition of colloid in the interior of the gland. Crossly the gland becomes firmer. The hyperplastic epithelium becomes less hyperplastic and this change is accompanied by a fall in the basal metabolic rate. The decline usually reaches a minimum in ten to twenty days, and thereafter the basal metabolism tends to level off somewhere between the original level and the minimum level.

The safest time for surgery is, of course, at the minimum level, and patients who may require thyroidectomy should not be treated with iodine except in preparation for operation. After they have received it for longer periods they are "iodine-fast."

In 1943 Astwood²⁰ introduced *thiouracil* in the treatment of hyperthyroidism. This drug interferes with the formation of thyroxine by the thyroid. The gland becomes markedly hyperplastic yet the basal

metabolic rate falls slowly and if administration of the drug is continued it will generally reach the levels of hypothyroidism. The rate of fall on ordinary doses of the drug is slow of the order of 1 point per day in the basal metabolic rate. The effect may be delayed if the patient has received previous iodine medication and has thus accumulated a store of thyroxin.

About 14 to 20 per cent of the patients receiving this drug develop unfavorable reactions to it necessitating its withdrawal. The most important and one of the most frequent of these reactions is agranulocytosis. Fatalities have been reported as the result of this and the number may well increase if vigilance in following the blood count is relaxed. Unfortunately agranulocytosis may develop even after a patient has taken the drug for long periods without difficulty. Penicillin has proved of value in reducing the mortality of those patients who develop this complication.¹

This uncertainty in the side effects of thiouracil has restricted its use in many clinics to the preoperative preparation of iodine fast and iodine sensitive patients and to the preparation of very severe cases which formerly required two stage operations. There are a number of drugs with a similar effect, thiobarbital and propyl thiouracil are perhaps the most important tested thus far. The incidence of unfavorable reactions is about the same for thiobarbital but appears on the basis of limited experience to be decidedly lower for propyl thiouracil. If further experience substantiates this claim the latter drug may well supplant the earlier one.

After preparation with these drugs the gland is hyperplastic and much more difficult to operate on than the gland of a patient prepared with iodine. For this reason where no contraindication to the use of iodine exists many surgeons give iodine for the last week or ten days to patients who have been prepared up to that point with thiouracil.

Should a drug be developed which would suppress thyroid activity controllably and for an indefinite period of time without unfavorable side reactions it would presumably make surgical excision unnecessary in most diffuse toxic goiters. The nodular goiters would still require excision because of the occurrence of malignant disease in 5 to 7 per cent of such glands.²

While iodine is still the safest drug in the preparation of the ordinary patient with hyperthyroidism it should be noted that it is capable not only of producing skin rashes but of producing hyperthermia in sensitive individuals. Barker and Wood³ reported several instances of this in 1940 and we have subsequently had occasion to observe two such cases.

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PATHOLOGIC PHYSIOLOGY OF HYPERPARATHYROIDISM

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THE clinical entity of hyperparathyroidism has been established on a firm anatomic and chemical basis. The original clinical descriptions of the early cases¹⁻³ have been amply confirmed by further reports. Von Recklinghausen⁴ described the pathology of the bones in this disease. Castleman and Mallory⁵ clearly demonstrated the pathological changes in the glands and classified them in a highly practical form. Cope⁶ later proved that hyperparathyroidism never occurs in the presence of normal parathyroid glands.

The chemical changes induced by the parathyroid hormone are well known—an increased blood calcium, a reduced blood phosphorus, and an increased urinary excretion of both. These effects not only are noted in patients with hyperparathyroidism but may be reproduced by injection of the hormone into human beings and into animals.⁷ The blood phosphatase is usually elevated when bone changes are present.

MECHANISM OF ACTION

The action of the parathyroid hormone is thought at present to be initiated only by chemical or humoral stimuli. Significant fluctuations in the volume and weight of the parathyroid glands have been produced by varying the amounts of calcium, phosphorus and vitamin D in the diets of rats.⁸ By means of cross perfusion experiments reduction in blood calcium was found to stimulate the glands to activity.⁹ Dragstedt¹⁰ was unable to detect a change in the blood calcium upon prolonged stimulation of the sympathetic nerve supply to the glands. Attempts to show an influence upon the parathyroids by other endocrine glands have been unsuccessful.

The focus of action of the hormone was originally thought by Collip⁷ to be on bone. Albright¹¹ contended that the action was primarily on the kidney. Recent experiments indicate that the hormone may act on both simultaneously. Hypercalcemia may be detected shortly after administration of a dose of parathormone in both human beings and animals. Histologically lesions in the bones of animals are noted within twenty hours after injection of the hormone.¹²

The continued operation of the biochemical processes initiated by

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hyroid hyperactivity eventually produces a series of complications which may ultimately result in death unless the hyperparathyroidism is surgically relieved. The glandular hyperactivity results in the withdrawal of calcium from the bones. The mobilized calcium is eliminated in the urine rather than in the feces, and varying amounts may be deposited in the kidney parenchyma to remain as such or to form pelvic calculi. The sequelae in untreated cases may be multiple fractures, large cystic areas in the bones, numerous skeletal deformities, renal lithiasis, urinary tract infection and, at times, fatal renal insufficiency.

CLINICAL TYPES

Symptoms due to the metabolic disturbance itself are of a general nature and do not direct attention to the parathyroid glands. Hyperthermia may induce weakness, sluggishness, constipation, polyuria and dysuria. Often these symptoms are not present, and, even when present, diagnosis is extremely difficult. The first instance of asymptomatic

TABLE 1.—INCIDENCE OF HYPERPARATHYROIDISM IN UROLITHIASIS

Author	No. of Cases	Types of Cases	Per Cent with Hyperparathyroidism
Albright, ¹² Mass. Gen. Hosp., 1937	1206	Calcium phosphate stone	5.0
Albright et al., ¹² Mayo Clinic, 1938		Stone (all types)	0.2
Albright, Univ. of Pa., ²⁵ 1933-1945	1116	Stone (all types)	1.1

hyperparathyroidism, with characteristic chemical findings and confirmed at operation, was accidentally discovered by Keating and Albright,¹² in confirmation of the earlier prediction of Albright, who predicted that such cases might be found.

The classic variety of the disease with osteitis fibrosa cystica generalisata, once thought to be the sole clinical form, is not so common as is the form associated with urologic complications. Several studies^{12, 13, 14} have shown that the complication of renal calcification occurs in well over 65 per cent of cases of hyperparathyroidism, and the group far exceeds the number of cases with demonstrable bone disease alone.

Patients with renal stones are routinely studied in many hospitals for discovery of hyperparathyroidism as an etiologic factor in urolithiasis.

The incidence of urolithiasis in three series is given in Table 1. Albright, Aub and Bauer¹⁷ have emphasized that hyperparathyroidism is a disease which is pleomorphic in form and variable in its clinical and symptomatic manifestations. The larger number of cases reported by these authors, as well as by Keating and Cook,¹² may well

be due to the recognition of patients with minimal findings who would not be discovered without special study. The incidence of the disease from three clinics is shown in Table 2.

TABLE 2 —INCIDENCE OF HYPERPARATHYROIDISM

	No. of Cases
Mass General Hospital ¹⁸	
1929-1942	67
Mayo Clinic ¹²	38
1942-1945-24	
1929-1942-14	
Hospital University of Pa. ¹⁴	
1933-1945	13

DIFFERENTIAL DIAGNOSIS

The chemical basis for the differential diagnosis of hyperparathyroidism has been well described by Albright and his associates¹⁹ but there are numerous diseases or clinical syndromes which may mimic hyperparathyroidism in certain aspects. The first of these is the simple cyst of bone. The appearance of this cyst on roentgen study may resemble that observed in von Recklinghausen's disease. Its presence too is often made known subsequent to a fracture. In the case of a simple bone cyst the calcium and phosphorus of the serum and urine are nearly always normal. In other instances bones which are the seat of metastatic carcinoma may show the same cystlike appearance plus extensive demineralization of the skeleton. When hyperparathyroidism is suspected the finding of generalized demineralization frequently aids in diagnosis but skeletal decalcification due to other causes may occur and when it does is often associated with significant hypercalciuria. In the osteoporosis of hyperthyroidism senility or the menopausal state and in that following immobilization of fractures and enforced bed rest calcium is mobilized from the bones the blood calcium may be elevated and there is usually mild to moderate hypercalciuria. Albright and his co-workers²⁰ state that the demineralization of hyperparathyroidism is usually accompanied by increased blood phosphatase whereas in osteoporosis with failure of reformation of bone the value is normal. Only by careful clinical evaluation of the patient and repeated blood calcium and phosphorus determinations can the diagnosis of hyperparathyroidism be established or excluded.

RENAL INSUFFICIENCY

The pathologic physiology of hyperparathyroidism may be modified in renal insufficiency. Severe degrees of renal damage subsequent to calcium deposition in the kidney and to superimposed infection are seen in the final stage of hyperparathyroidism. Phosphorus retention and a coincidental reduction of the blood calcium may occur.^{21, 22} Previously altered blood calcium and phosphorus levels as a consequence

may return to within normal limits. The diagnosis on chemical grounds, therefore, may be difficult. Due to the renal insufficiency the urinary excretion of calcium and phosphorus may be greatly reduced, so that a further aid in diagnosis is absent. In such cases the clinical findings and the presence of a consistently "high normal" level of blood calcium, as advocated by Cope,²³ are the chief means of diagnosis.

ERRORS IN DIAGNOSIS

Review of the records of our patients operated upon for suspected hyperparathyroidism discloses eight in whom no tumor was found (Table 3). In one of the eight an adenoma was found at a second operation in another hospital. In the remaining seven the preoperative diagnosis of hyperparathyroidism was later proved to be incorrect.

As a basis for diagnosis, blood calcium and phosphorus determinations must be repeated frequently in suspected hyperparathyroidism. One of the common sources of error is use of the urinary calcium ex-

TABLE 3—UNSUCCESSFUL NECK EXPLORATIONS FOR
HYPERPARATHYROIDISM

Diagnosis	No. of Cases
Failure to find an adenoma	1
Osteoporosis of the menopausal state	1
Osteoporosis of immobilization for fracture	1
Renal dwarfism	1
Error in metabolic study	1
Metastatic carcinoma of bone	1
Hypercalciuria of unknown cause	2
Total	8

cretion as a means of diagnosis. The calcium balance under normal conditions may vary significantly with diet, age and body activity.²⁴ Metabolic study to determine the urinary calcium excretion is usually conducted according to the program of Bauer and Aub.²⁵ Great care must be taken to insure accuracy in feeding the proper diet and in collecting the urine specimens.

A serious mistake was found to have occurred during the study of calcium excretion in one of our patients. For a week before and during the period of urine collection large doses of ammonium chloride were administered to acidify infected urine. Hypercalciuria attendant upon the use of this drug is well known. The calcium excretion amounted to over 1400 mg. in a three day metabolic period. The patient had bilateral renal stones but presented a normal blood chemical picture. On the basis of the hypercalciuria, exploration for a parathyroid adenoma was done. No tumor or hyperplasia was found, during a six year follow-up this patient has remained well subsequent to the removal of the calculi. This instance clearly demonstrates a com-

mon error in conducting metabolic studies. Another of our patients was mistakenly operated upon in search of a parathyroid tumor after discovery of a pathologic fracture through a bone lesion which was an undiagnosed metastatic carcinoma. Although the serum calcium was normal, the urinary excretion was four times normal, owing to the rapid mobilization of calcium from the skeleton.

HYPERCALCAINURIA IN DIFFERENTIAL DIAGNOSIS

The increased urinary excretion of calcium found in hyperparathyroidism is often utilized in diagnosis when the blood findings and clinical picture are inconclusive. This determination may assume some importance in borderline cases and may be the deciding factor in the decision to explore the neck.

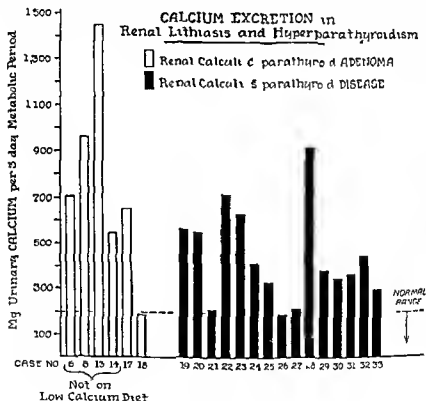


Fig. 535

In patients with urolithiasis Riegel, Royster, Gislason and Hughes⁶ demonstrated that 14 of 15 patients studied exhibited hypercalcaemia of unknown etiology (Fig. 535). These individuals did not have hyperparathyroidism or any other known cause of the hypercalcaemia. The excess calcium excretion was associated with moderately impaired renal function in 50 per cent of the patients studied. The conclusions

drawn were that moderately diseased kidneys may excrete abnormally large amounts of calcium and that hypercalcaemia may not be a reliable diagnostic sign of hyperparathyroidism. The renal damage in these patients was not severe enough to cause renal insufficiency.

Serial urinary calcium excretion studies over a period of years have been recorded in this clinic in a number of instances. Comparison of these studies with those of renal function indicates that, as a rule, as the renal function becomes reduced the calcium excretion rises. When the stage of marked nitrogen retention, severe temporary damage due to infection, or ureteral block is reached, the urinary calcium may be reduced and blood phosphorus retained as noted by Albright and his co-workers.²¹ Figure 536 shows the urinary excretion of calcium and

Relation of Calcium Excretion and Renal Function

Case No.	Clinical Estimation of RENAL FUNCTION	URINARY CALCIUM per 3-day metabolic period
*19 ♂ 1937 Bilateral renal calculi	MODERATELY IMPAIRED Conc - 1023 PSP - 60 % Diodrast clearance - Rt. none Lt. delayed	492 mg
1946	MARKEDLY IMPAIRED Conc - 1012 PSP - 40 %	561 mg.

Fig. 536.

the state of the renal function of a patient in 1937 and in 1946. After a nine year interval following several episodes of recurrent bilateral urolithiasis, the renal function was notably decreased and the urinary calcium excretion significantly increased. The initial metabolic study was done with the patient on the regular hospital diet; during the last collection of urine for calcium determination, the daily diet contained less than 0.1 gm. of calcium. Had the patient been fed the low calcium diet in 1937, the initial excretion values in all probability would have been near or within the normal limits of 200 mg. during a three day metabolic period. The levels of the blood calcium, phosphorus and phosphatase and of the blood urea nitrogen were normal. Thorough exploration of the neck and the upper mediastinum with careful dissection failed to reveal a parathyroid tumor.

SUMMARY AND CONCLUSIONS

1. The important aspects of the pathologic physiology of hyperparathyroidism are discussed.

2 The problems in differential diagnosis are presented with special reference to

- (a) errors in diagnosis of other bone diseases,
- (b) errors in the technique of metabolic study,
- (c) interpretation of the finding of hypercalcaemia

3 It is shown that calcium excretion may be increased in association with mild to marked impairment of renal function

4 Hypercalcaemia alone may not be a reliable diagnostic sign of hyperparathyroidism

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THE HEALING OF FRACTURES

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THROUGHOUT the history of medicine, from the days of Hippocrates and Galen to modern times, a tremendous amount of writing and experimental work has been concerned with the healing of fractures. Nearly 4000 papers were published on this subject prior to 1940¹ and many more appeared during World War II. Much of this enormous literature is concerned with diametrically opposing opinions and thus far a large part has proved valueless in the clinical treatment of fractures. Yet it is only by a thorough understanding of basic physiological processes that progress can be made in the practical treatment of fractures. Watson Jones² says "The principles of the treatment of fractures must conform to biological laws and a knowledge of these principles is of greater fundamental importance than an acquaintance with the mechanical details of splints. The training of the fracture surgeon must begin with the physiological and pathological reactions of living tissues. Only after that does the art of surgery develop with the aid of mechanical apparatus and manipulative technique."

A knowledge of the healing of fractures is important from many standpoints. Fractures constitute nearly a fifth of all industrial accidents and if the healing time of fractures could be decreased an enormous saving to industry would result. Fracture healing is often a serious problem in older people in whom delayed union occurs frequently and with the increasing number of elderly persons in the population a method of preventing delayed union assumes greater importance. Of more value to the patient than time saving would be the diminution in joint stiffness and soft tissue wasting which would be possible if delayed union could be prevented or if the "normal" healing time could be decreased allowing joint and muscle function to be resumed earlier.

Recent clinical advances in the mechanical fixation of bone have added much to the treatment of fractures but have left the basic problem untouched. Only by a thorough knowledge of the physical and chemical factors which contribute to bone healing can we hope to prevent delayed and nonunion and speed the "normal" healing time of fractures.

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THE ANATOMY OF THE HEALING FRACTURE

Although many different opinions still exist over certain details of the anatomy of fracture healing, a fairly clear picture of the basic process has evolved. Until about twenty-five years ago almost all studies of fracture healing were occupied with gross and microscopic anatomy. Then emphasis shifted to physiochemical changes. But the development of new histological techniques has made possible several recent studies^{1-3, 9} based on both human and animal fractures, which have challenged some of the older anatomical concepts and added significant new evidence.

In general the healing of a wound of bone follows the same principles as the healing of a wound of other tissues, but in addition bone healing involves deposition of calcium salts. The sequence of events may conveniently be thought of in the following stages, although there is considerable overlapping of the processes.

1 *Tissue Necrosis and Hematoma Formation*—When a fracture occurs, the periosteum is lacerated and necrosis takes place in the surrounding soft parts. A hematoma develops between the fragments and in the surrounding tissues, and after several hours becomes a blood clot.

2 *Fibrinous Clot Formation*—Fibrin is laid down within the hematoma after several more hours, forming a fusiform mass about the fracture site.

3 *Fibrous Tissue Formation*—Undifferentiated fibrous connective tissue replaces the fibrinous clot by capillary growth from the periosteum, endosteum, Haversian canals, and surrounding soft tissues. Inflammatory cells infiltrate the clot. During these early stages regressive changes are taking place in the bone ends and detached fragments.

4 *Fibrocartilaginous Callus Formation*—Until about the fourth day healing has been similar to that of any soft tissue wound, but now begins the process peculiar to bone. Condensation of the fibrous callus is noted, an intercellular hyaline matrix is laid down, and chondroblasts begin to form from fibrous connective tissue cells between the bone ends. (The amount of cartilage formed is thought to be influenced by the amount of motion of the bone fragments during healing—the more motion, the more cartilage.) Large spindle-shaped cells appear within the callus, developing either from the proliferation of osteoblasts of the periosteum and endosteum, or by metaplasia of connective tissue cells.

5 *Bone Formation from Fibrocartilaginous Callus*—Fibrocartilaginous callus is replaced with new bone by (a) intramembranous new bone formation and (b) endochondral ossification. Intramembranous new bone, replacing the fibrous connective tissue of the callus, is formed by proliferation of the large spindle-shaped cells described above and by intercellular deposition of calcium salts, which begins soon after the new tissue is laid down.

Bone replaces the cartilage between the fragments by the process of endochondral ossification. The cartilage cells die and calcium is laid down in the intercellular matrix. Dead cartilage cells are removed subsequent to ingrowth of blood vessels, and osteogenic cells invade the region and deposit bone matrix.

The latter part of the process of ossification is occupied with the structural reorganization of the callus. Excess callus is absorbed and the marrow cavity is reformed. It has been shown by experiments on rats¹⁰ that the breaking strength of fractures rises with the formation of the primary callus (sixth to twenty first day), and falls with the development of the medullary cavity (twenty first to thirtieth day). It then shows a slow rise until normal breaking strength is gained (forty fifth day).

Certain details of this process are still the subject of considerable debate. Few medical subjects have produced more violent controversy than the origin and specificity of the osteoblast. Originally the osteoblast was thought to have specific power to lay down bone. In 1926 Leriche and Policard¹¹ denied the existence of any specific bone forming cell and stated that connective tissue cells were changed into bone cells by metaplasia of fibrous connective tissue. The experiments of Huggins¹² demonstrated that under an altered environment nonosseous connective tissue may acquire osteogenic properties. Bone formed in a fascial transplant to the dogs bladder from which urine had been diverted and also around a bladder transplant to fascia and connective tissue. Admitting that bone can form by metaplasia in a nonosseous surrounding without the aid of the osteoblast some authorities have stated that the usual method of bone formation at the fracture site is through the specific function of the osteoblast.^{1, 4, 13} Others^{14, 15, 16} have said that bone cells are formed by metaplasia of connective tissue cells. Further experimentation must determine whether a specific bone forming cell exists and whether it can be formed by metaplasia.

Another controversy within the field of bone formation is the question of ossification: a specific process or a general process. The evidence indicates that there is a difference in the substance of the callus other than the deposition of calcium salts. Many believe that this intracellular substance or matrix differs from that of ordinary fibrous connective tissue.

THE INFLUENCE OF LOCAL FACTORS ON THE HEALING OF FRACTURES

Factors at the fracture site are of much greater importance in determining the quality of healing than are general metabolic and constitutional factors. Repeated experiments have demonstrated that variations in conditions at the fracture site may influence healing greatly, whereas little change is noted when systemic conditions are altered.

Physiochemical Factors.—The physiochemical changes which take place at the fracture site have been studied intensively during the last two decades. In 1923 Robison¹⁷ discovered the enzyme, phosphatase, in the ossifying cartilage of young rats and rabbits which, in an acid medium, hydrolyzed glycerophosphate and hexosephosphate yielding phosphoric acid. Robison postulated that during ossification this hydrolysis brought about a local increase of phosphate ions causing supersaturation of calcium phosphate; deposition of bone salt then took place. Robison stated that phosphatase was secreted by osteoblasts and hypertrophic cartilage cells, while others¹⁸ asserted that it was the product of dead tissue cells. Considerable circumstantial evidence has been brought forth to substantiate Robison's hypothesis.¹⁹⁻²⁴ Because the content of phosphoric esters hydrolysable by phosphatase is low in blood plasma, the source of the substrate for phosphatase has been searched for elsewhere. Glycogen may serve as the source because the content of glycogen increases in hypertrophic cartilage prior to ossification and disappears during ossification.^{25, 26, 27} These investigations bring up possibilities for prevention of delayed and nonunion and for speeding healing. In experimental fractures some progress has been made by Armstrong²³ and Blum²⁴ who have accelerated healing by local implantation of substrates of phosphatase. Because the concentration of phosphatase is low in infected fractures it has been inferred that the delayed union which often results is due to interference with the normal action of phosphatase.²²

The humeral theory of fracture healing, which claims that bone formation is a biochemical phenomenon independent of direct cell participation, has been advocated by Murray.^{8, 16, 18, 28, 29, 30} He states that bone can form anywhere in the body if the following four conditions are present: (1) tissue death; (2) growth of granulation tissue; (3) local concentration of calcium; and (4) proper pH. He has produced bone by implantation of calcium salts in traumatized tissues away from bone. He believes that the acid pH found at the fracture site in the first few days acts as a decalcifying agent and that the calcium is held in place by an affinity for the fibrin of the fibrinous clot. As the pH is raised by absorption of the necrotic tissue a point is reached where phosphatase becomes active and calcification begins. Although, according to Murray, most of the calcium comes from near the fracture site, this opinion is not held by Urist and Johnson¹ who have stated that the major supply comes from the blood stream.

Blood Supply to the Fracture Site.—An adequate blood supply is necessary for the proper healing of fractures. The common sites for delayed and nonunion in fractures—namely, junction of the middle and distal third of the humerus, carpal scaphoid, neck of the femur, and junction of the middle and distal thirds of the tibia—all have a precarious blood supply. Johnson³¹ showed that in the repair of fractures of the shaft, the nutrient vessels were the most important for normal

healing, the metaphyseal next, and the periosteal last. Just how circulation influences fracture healing is not definitely known. Murray³⁰ says it acts by changing the biochemistry of the tissue fluids rather than by supplying nutrition to the fracture site.

Mechanical Factors.—Imperfect apposition of fragments, extensive tissue necrosis, interposition of material between the bone ends and inadequate immobilization are local factors which may cause delayed or nonunion. Considerable clinical and experimental evidence has established these factors as the most important causes of poor healing in clinical fractures. Experiences in World War II emphasized the necessity of an adequate excision of all devitalized tissue to prevent infection and promote optimal healing in gunshot fractures. Swartz³¹ found that the most significant factor in the rate of healing in experimental fractures in animals is the degree of apposition of the fragments, and Watson Jones³² said, 'There is only one cause of nonunion of fractures with continuous hematoma between the fragments—the cause of nonunion is inadequate immobilization.'

Metals Used for Internal Fixation.—Venable^{33, 34} and Key³⁵ have recently warned against the use of mixed types of metals for the internal fixation of bone. When different elements are placed in bone an electrical force is generated by the creation of a battery, and corrosion of the bone occurs, a process termed by Venable "electrolytic osteitis." The danger is especially great when both stainless steel and vitallium are used at the same operation, and it is imperative for a hospital operating room staff to avoid mixing plates and screws of different composition and to supply only alloys which are known to remain passive in tissues.

INFLUENCE OF GENERAL METABOLIC AND CONSTITUTIONAL FACTORS ON FRACTURE HEALING

Calcium and Phosphorus Metabolism.—Since the discovery of methods for determining calcium and phosphorus concentrations in body fluids, numerous attempts have been made to assess the importance of these elements in the healing of fractures. In 1924 Peterson³⁶ concluded from experimental and clinical observations that there was a definite relationship between their concentration in the blood and bone formation. If the product of the calcium and phosphorus levels in the blood dropped below 30, nonunion occurred, delayed union resulted between 30 and 35, and optimal healing occurred with a product between 35 and 40. Studies made in this clinic by Ravdin and Jonas³⁷ and Ravdin and Morrison³⁸ did not confirm these observations. No definite correlation between the blood levels of calcium or phosphorus and bone healing was found in an analysis of a series of clinical fractures in normal individuals and experimental fractures in dogs. Subsequent experience has verified these findings. Study of calcium and phosphorus balances has not clarified the problem.³ Al

though negative calcium and phosphorus balances were shown to occur following fractures, addition of these elements to the diets of experimental animals or to the well balanced diet of patients with fracture has not improved fracture healing. On the other hand, large doses of calcium may actually inhibit healing.³⁹

Opinions differ concerning fracture healing in rachitic bones and the role which vitamin D plays. According to many textbooks rachitic bones heal promptly. Several investigators³⁹⁻⁴² observed retarded healing in rachitic bones of animals, which could be improved by addition of vitamin D to the diet. It is unlikely that vitamin D deficiency plays a significant role in delayed fracture healing in humans. The knowledge that an *overdose* of vitamin D may cause delayed or nonunion seems of more clinical importance.

Injections of parathormone have been tried in cases of delayed and nonunion on the theory that parathormone would raise the level of calcium in the blood thereby making it available for deposit at the fracture site. Both clinical and experimental results showed the futility of such injections, apparently parathormone draws calcium from the callus just as from the rest of the skeleton.⁴⁴

Protein Metabolism.—Fracture healing is intimately connected with the growth of connective tissue and one would expect to find it affected by variations in protein metabolism. Studies in this department have shown that hypoproteinemia produces delay in the healing of soft tissue wounds in dogs.⁴⁵⁻⁴⁶ Since then it has been conclusively demonstrated that an adequate dietary intake of protein is of great practical value in the healing of soft tissue wounds of humans. Rhoads and Kasinskas,⁴⁷ working in this laboratory, observed that severe hypoproteinemia in dogs retarded the formation of bony callus after experimental fracture. In clinical fractures, however, hypoproteinemia has not been demonstrated to be a significant factor in causing delayed and nonunion.

Several very provocative investigations have recently been made of protein metabolism after trauma. Nitrogen balance studies of Howard⁴⁸ showed that the average loss of nitrogen in a group of patients with fracture was 225 gm over an average period of thirty five days. A smaller loss of nitrogen following osteotomy than following fracture was an interesting observation. The loss could not be accounted for by fever per se, atrophy of disuse, or loss of muscle substance at the site of injury, but was probably related to the effects of the products of devitalized tissue on general body metabolism.⁴⁸⁻⁴⁹ Cuthbertson⁵⁰ made the interesting observation that massage and passive motion of a limb reduced the nitrogen excretion after fracture. This may have practical importance and may place added emphasis on early ambulation, active motion, and other physical therapeutic agents in the treatment of fractures.

General metabolic factors are of greater importance in compound

than in simple fractures, particularly in chronically infected compound fractures. Studies made in the Army during World War II by Lyons⁵¹ revealed that patients with chronically infected gunshot fractures had considerable deficiencies in hemoglobin, red blood cells and tissue proteins, associated with a decreased blood volume and an increased interstitial fluid volume. Diet alone was effective in producing a positive nitrogen balance in these patients, but control of the infection was necessary before a regeneration of hemoglobin and red blood cells could be produced, tissue proteins replaced, and normal fracture healing instituted.

Carbohydrate and Fat Metabolism.—Careful studies of the effect of diet on the breaking strength of fractured fibulas in rats have been made by a group of investigators at Yale.^{5 6 10 14 52 53 54 55} Both a high fat and a high carbohydrate diet were somewhat detrimental to fracture healing.

Vitamins.—The effect of vitamin D on fracture healing was discussed above. By using labeled radioactive strontium, Copp⁴³ showed that when a vitamin A deficiency existed in experimental animals the fracture callus was smaller and calcification less active. Mellanby⁵⁶ stated that the function of vitamin A was to control the action of osteoblasts. Vitamin C deficiency results in a diminution of the amount of connective tissue callus following a fracture but has no effect on calcification.⁵⁷ Considerable deficiencies of vitamins A and C must be present before these results are noted. Supplements of vitamins A and C are needed only when hypovitaminosis exists and their addition to the normal diet is of no value in fracture treatment. Deficiencies in man rarely, if ever, are severe enough to cause delayed or nonunion.

Hormones.—The healing of fractures is not significantly influenced by hormone therapy, according to investigations made up to this time. Pollock⁵⁸ reported that estrin accelerated osseous union but Brush⁵⁹ found retardation of fracture healing when stilbestrol was given to rats.

Constitutional Factors.—Murray¹⁸ has stated that delayed and nonunion occur in places not in people. Constitutional factors appear surprisingly unimportant in causing delayed and nonunion in man and even the general state of health seems to influence fracture healing only slightly. The delayed union which is commonly seen in the elderly, however, will become an increasingly important problem in surgery. In 1940 there were 9 000 000 persons in the United States aged sixty five or over, but by 1960 it is estimated that the number will have increased to 13 600 000.⁶⁰ The prevention of delayed union in the elderly offers a real challenge to the surgeon treating fractures.

While serving with the 20th General Hospital in India during World War II I had an unusual opportunity to observe clinically the influence of general and constitutional factors on the healing of fractures. Both Chinese and American casualties were cared for during the

Burma Campaigns and a large percentage of the patients with fractures were observed from the time of wounding until healing took place. The average American soldier was in much better general condition than the Chinese, he was slightly younger, his diet was more nutritious especially in calcium and vitamins, he showed a lower incidence of associated medical diseases and his level of circulating hemoglobin and red blood cells was higher. The hospital treatment of the two groups was identical however. Compound fractures of the humerus and femur of both races were carefully analyzed^{61 62} (Table 1). The average time of bony union as evidenced by clinical

TABLE 1—COMPARISON OF FRACTURE HEALING IN CHINESE AND AMERICAN SOLDIERS
(142 Compound Fractures from the North Burma Campaign)

	Chinese	American	Total
Average age	26 years	23 years	
Average hemoglobin on admission	11.5 gm	13.0 gm	
Number of fractures			
Humerus	37	23	60
Femur	70	12	82
Total	107	35	142
Average time of bony union including delayed union			
Humerus	8.7 weeks	8.9 weeks	
Femur	14.6	14.0	
Number of nonunions	6	2	
Per cent of nonunions	5.6	5.7	

and x-ray examination was not significantly different in the two groups. Out of the total of 142 cases there were eight instances of nonunion, all but one had bone loss of over 2 inches which was considered to be the cause of nonunion.

Although the number of fractures analyzed is small, the results bear out our very definite clinical impression—gained from the treatment of almost two thousand fractures, both simple and compound, about equally divided between the two races—that no significant difference exists in fracture healing between young Chinese and American soldiers.

PRINCIPLES OF FRACTURE HEALING APPLIED TO TREATMENT

Proponents of various forms of fracture therapy have a tendency to rationalize principles of fracture healing to fit proposed methods of treatment. Present knowledge of fracture healing, however, favors no specific method but emphasizes the following principles:

1. Early reduction with a minimum of soft tissue destruction. Delayed reduction may often be successful but causes more soft tissue injury and retards fracture healing.

- 2 The assurance of a good blood supply to the bone fragments
- 3 Immobilization of the bone fragments until healing of the fracture has occurred
- 4 Active motion of all parts of the body not required for immobilization of the fracture
- 5 A well balanced diet with special attention to proteins. There is no indication for supplementary calcium, phosphorus or vitamin D.
- 6 A thorough debridement of compound fractures with institution of chemotherapy, early replacement of blood loss and a diet high in protein and vitamin C.

Open reduction with internal skeletal fixation is advantageous when adequate reduction and fixation cannot be obtained by closed methods and when early joint function is vital. The dangers of internal skeletal fixation—infection, damage to blood supply, and electrolytic osteitis—must always be weighed against the advantages.

At present no substance has been introduced which when given generally or locally to normal fracture patients will speed healing significantly. The surgeon treating fractures should not be complacent. Experimental work has pointed out several possible avenues in which speedier healing may be effected and before many years a decrease of normal healing time should be accomplished.

SUMMARY

- 1 The surgeon treating fractures must be thoroughly familiar with the principles of fracture healing.
- 2 Anatomical stages in the healing of fractures are: (a) tissue necrosis and hematoma formation; (b) fibrinous clot formation; (c) fibrous tissue formation; (d) bone formation; (e) bone formation.
- 3 General metabolic and constitutional factors are not as important in fracture healing as factors at the fracture site—viz., mechanical, physiochemical and circulatory.
- 4 The increase of the elderly in the population will make delayed union an increasingly important medical problem.

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PATHOLOGIC PHYSIOLOGY OF PROSTATIC OBSTRUCTION

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ANY discussion of the pathologic physiology of prostatic obstruction must concern itself with the evaluation of (1) the reaction and response of the smooth muscle of the bladder ureters and renal pelves to changing hydromechanical factors and (2) the effect of these changes on renal function

The end result of any obstruction in the urinary tract has its final measurement in terms of impaired renal function An obstruction at a pelvo ureteral junction or lower in the ureter acts directly on renal parenchyma producing hydronephrotic atrophy by means of pressure from pelvic and tubular dilatation and by superimposed anemic atrophy¹ Increasing prostatic obstruction has the same effect on the kidney (but is more lethal because both kidneys are involved) even though the result is not so direct due to the interposition of the bladder as a pressure cushion

NORMAL PHYSIOLOGY OF URINARY TRANSPORTATION AND SOME ANATOMICAL CONSIDERATIONS

Urine is transported from the kidney pelvis to the bladder by means of peristaltic waves which originate in the musculature of the pelvis and extend to the ureterovesical orifice A peristaltic wave travels approximately 3 cm per second not all waves reach the vesical orifice or are of the same amplitude From normal ureters urine is ejected into the bladder at varying intervals (14 to 38 seconds) Both ureters may contract at different times and at different rates There is complete cessation of ureteral peristalsis however during active bladder contractions This reflex control of ureteral peristalsis aids in preventing regurgitation of urine from the bladder through an open ureteral orifice during voiding The principal reason why urine does not regurgitate however is an anatomical factor—the oblique insertion of the ureters into the bladder wall with the resulting “valve formation”

The smooth muscle of the bladder wall has the same power as striated muscle to lengthen and to shorten thus accommodating to varying degrees of distention with approximately the same degree of tension The whole thickness of the muscular wall of the bladder known as the detrusor consists of an internal circular and an external longitudinal coat of smooth muscle which are not perfectly defined At the base of the bladder quite apart from the detrusor is the

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trigonal muscle, which is an extension of the longitudinal muscle of the ureters. This trigonal muscle passes over the posterior portion of the vesical orifice and extends downward along the urethra to the external sphincter. At the vesical orifice there is no marked muscular development—no true sphincter in the sense of the external urinary sphincter or the anal sphincter. There is, however, an interlacement of the circular and longitudinal muscles of the detrusor to form the “internal sphincter.”

The resting intravesical pressure is markedly raised only when the normal limits of bladder distention are reached. When this occurs, normal micturition is initiated by a contraction of the detrusor. As the intravesical pressure rises, the “internal sphincter” opens, aided apparently by a contraction-pull of the trigonal muscle on the posterior portion of the vesical orifice. The external sphincter then opens reflexly, and the bladder cavity empties itself of its total contents. Neither the internal nor the external sphincter can be opened voluntarily. The external sphincter, however, does have voluntary power to contract. Many studies have been made of intravesical pressure in normal individuals. Denny-Brown and Robertson² found that intravesical pressure at moderate volumes varied from 5 to 10 cm. of water. The pressure at the moment of “internal sphincter” opening varied from 18 to 43 cm. of water. Denny-Brown and Robertson state that the “internal sphincter” opens at a lower pressure, the greater the volume of the bladder contents. Actually, much higher intravesical pressures have been recorded in the normal bladder. The highest pressure recorded in Watkins³ series was 176 cm. of water.

There are no universally accepted figures that represent the hydrostatic pressure in the normal pelvis and ureter of man. Pressures recorded in experimental animals after complete ligation of the ureter (50 to 70 mm. of mercury)⁴ cannot be translated into normal clinical physiology.

PATHOLOGIC PHYSIOLOGY OF PROSTATIC OBSTRUCTION

The physiological response of both the mid-urinary tract (bladder) and the upper urinary tract (ureters and renal pelves) to prostatic obstruction follows the same general pattern—normal function is preserved, at first, through the compensatory hypertrophy of the smooth muscle. In continuing obstruction, however, this compensation readily gives away to decompensation, dilatation and atony, with resulting urinary stasis. Decompensation usually occurs in the upper urinary tract before beginning in the bladder.

Effect of Prostatic Obstruction on the Bladder.—As the detrusor and trigonal muscles hypertrophy in response to the greater effort of urination because of the prostatic obstruction, the bladder wall thickens and the bladder capacity lessens (Fig. 537). A reduced bladder capacity results in urinary frequency. When such a contracted bladder

sooner or later give way to decompensation—the bladder wall becomes dilated and atonic, residual urine increases, urination becomes more difficult, as well as frequent, and complete urinary retention may occur

Effect of Prostatic Obstruction on the Upper Urinary Tract.—Prostatic obstruction affects the upper urinary tract primarily through the changes that occur in the bladder wall. The increased muscle tone accompanying detrusor hypertrophy results in increased resistance at the ureteral orifices. The pelvic and ureteral musculature respond to this increased resistance in the same physiological manner as the detrusor. By means of hypertrophy of its muscular coats, the upper urinary tract compensates against the ureteral orifice resistance. Clinical studies (pyeloscopy, intravenous urography, urokinymography) of the upper urinary tract in prostatic and other partial obstructions have shown conclusively that this compensation is evidenced by an increase in the amplitude, rate and vigor of the pelvic and ureteral contractions.

Experimental studies of changing pressures in the ureter after complete ligation have been made,⁴ but there are no entirely satisfactory measurements of actual intraureteric or intrapelvic pressures in cases of experimental or clinical *partial obstruction*. On anatomical grounds the smooth muscle of the upper urinary tract is in no position to compete with the hypertrophy of the detrusor. Furthermore, any great increase in intraureteral pressure is immediately transmitted to the renal pelvis and renal parenchyma, as there is no pelvo ureteral "valve" to protect the renal function in the manner that the oblique insertion of the ureters through the bladder wall guards the upper urinary tract from the direct transmission of intravesical pressure.

In continued resistance at the ureteral orifices due to the constant increase of bladder tone as a compensation to prostatic obstruction, the hypertrophy of the smooth muscle of the upper urinary tract readily gives way to the dilatation and atony of decompensation. Muscular decompensation of the upper urinary tract almost always precedes decompensation of the bladder (Fig 537). Beginning dilatation of the upper urinary tract, however, does not necessarily mean a corresponding impairment of function. Clinical studies of ureteral function in partial obstructions have shown that a dilating ureter may maintain its physiological integrity for some time.⁵

Muscular and physiological decompensation of the upper urinary tract is much accelerated when the ureterovesical orifice becomes incompetent usually due to its dilatation as a result of increased intravesical pressure. In such a condition, vesico ureteral reflux readily occurs, and the renal pelvis, ureter and bladder become one freely communicating system (Fig 537). Ureteral reflux may remain a unilateral phenomenon, or may become bilateral. When bilateral, it is usually more marked on one side.

THE PATHOLOGIC PHYSIOLOGY OF THE EXTENSIVE SUPERFICIAL BURN

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THE past five years have brought an increased interest in the physiology of the burn. Civilian groups have been stimulated to further study by disasters such as occurred in St. Johns, Newfoundland and at the Coconut Grove in Boston. During the war the use of flame weapons and secondary fires in cities devastated by mass bombing also accentuated the problem.

The recent literature contains a number of excellent reviews of wide scope.^{1, 2, 3} Therefore, this paper summarizes briefly the physiology of the severe burn in the light of recent research and indicates where changes have been made in the generally accepted therapy.

LOCAL EFFECTS

The thermal injury is customarily defined in terms of the extent of body area involved⁴ and the depth of injury within that area. A first degree burn shows erythema of the skin but no vesication. A second degree burn shows partial destruction of the skin with formation of blisters. A third degree burn completely destroys the epidermis. Within this simple classification there is wide variation in the type of lesion produced. The area burned may be exposed to a moderately high temperature for a sufficient length of time to destroy just the epidermis itself, causing necrosis of the epidermis with marked edema and cellular infiltration of the subjacent dermis. On the other hand the third degree burn may be due to prolonged exposure to higher temperatures which will produce a thick, dry, coagulated sheet of tissue with much less apparent immediate edema.^{5, 6} Patients with the latter type of burn are apt to show less severe shock and immediate systemic reaction although the amount of tissue destroyed is actually greater.

Following the injury there is an immediate onset of intense pain and an outpouring of plasma into the skin and subcutaneous tissue of the burned area. This fluid is similar to plasma in composition⁷ as is the lymph that drains from the burned area.⁸ The bulk of this plasma loss occurs within the first twenty four to thirty six hours and causes hemoconcentration in proportion to the depth and extent of the burn.⁹ Toward the end of this period there is progressive plugging with

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fibrin of lymphatics and capillaries within the burned area.⁸ Roughly forty eight hours after injury the circulation begins to re establish itself in all areas except those completely coagulated by heat.

During the first week after injury there is a gradual demarcation of dead from living tissue. Proteolytic enzymes in the acid medium of the wound proceed to split the dead slough away from the underlying granulations. The devitalized tissue is invaded by bacterial organisms and control of infection becomes a major problem of burn management.¹⁰ At the same time there is regeneration of epithelium in the area of second degree burn from the undestroyed hair follicles and sweat glands. There is continued loss of fluid and protein from the granulating areas, which in a severe burn may equal the urinary nitrogen loss.¹¹

SYSTEMIC EFFECTS

The general clinical course of the patient with a severe thermal burn may be roughly divided into three phases: shock, delayed visceral damage or 'toxemia,' and the period of repair.

Shock—During the first twenty four to thirty six hours the phenomenon of acute burn shock runs its course. In common with other types of shock, there is low blood pressure, low cardiac output, increased peripheral resistance¹² and a diminished blood volume.¹³ Burn shock differs from hemorrhagic shock in that the decrease in blood volume is primarily due to a loss of plasma with consequent hemoconcentration. There is increased viscosity of the blood and red blood cells are trapped in sluggish peripheral portions of the circulation.¹⁴ Red cells which are exposed to heating in the burned area become spherocytic and more fragile, ultimately lysing and releasing hemoglobin into the plasma.¹⁴

The plasma protein, particularly the low molecular weight albumins, leaves the circulation through the damaged vessels, passes into the burned area and is lost.

There is hyperglycemia, an increase in blood lactic acid and a decrease in carbon dioxide content of the plasma. Hyperglycemia and an increase in lactic acid have been observed in medical as well as in surgical shock.^{15, 16} The cause is not clearly understood. Experimental burns in rats and rabbits produce a fall in muscle glycogen, but this has not been corroborated in the case of human beings.^{17, 18} An increase in lactic acid conversion from muscle glycogen may cause a rise in blood sugar through conversion of lactic acid into glycogen and glucose in the liver. Since there is some liver damage in a severe burn the high level of lactic acid in the blood may be the result of the impaired ability to convert lactic acid. The decrease in alkali reserve is probably due to accumulation of fixed organic acids to some extent. In addition, sodium enters the burned area in exchange for potassium but in skin this does not represent a significant loss of

alkali. Only in burns with extensive muscle damage is there marked trapping of sodium in the tissues.¹⁹

Again, depending on the type of burn, other factors besides fluid loss are undoubtedly operating. Experimental high temperature burns can cause death from shock without significant fluid loss.²⁰

Shock may be expected in adults with third degree burns involving 15 per cent or more of the body area. The patient with a third degree burn involving 70 or 80 per cent of the body area usually dies within twenty-four hours after injury.

Pulmonary edema may also cause death during the first day. This appears subsequent to the inhalation of hot wet air or after prolonged inhalation of smoke. Very frequently these patients will have burns about the head and upper thorax.²¹ In the case of burned patients who have not been subjected to such inhalations, the massive intravenous infusions for the treatment of shock do not appear to cause pulmonary embarrassment.

Delayed Visceral Damage or "Toxemia."—The second clinical phase extends from the beginning of the second day following injury to the end of the second week. The patient with a third degree burn covering about 30 per cent or more of the body surface is in a critical state during this period. Patients with more than one third of their skin completely destroyed usually die within the first ten or twelve days after injury.

At the beginning of the second day the rate of plasma loss into the burned area has greatly decreased. The area is tense with protein-rich edema fluid. The fluid volume of the blood stream has been restored so that pulse and blood pressure are near normal. The temperature is usually elevated several degrees, particularly toward the end of the second day, when circulation begins to re-establish itself throughout the burned area. The levels of protein and sodium chloride in the plasma tend to be low in spite of replacement therapy, the carbon dioxide content of plasma has usually returned to near normal. The secondary anemia is quite apparent at this time. The patient is slightly nauseated and may vomit. He is drowsy, somewhat disoriented and occasionally manic. The very severely burned patient may be comatose.

The hemoglobin from the lysed red cells has been cleared from the plasma at this stage, and the serum bilirubin is usually moderately elevated. Liver damage is demonstrable, although severe injury to this organ is usually more rare now than it was during the period when tannic acid therapy was used,²² this point being discussed in more detail under Local Therapy. There are often some bromsulfalein retention, a decrease in benzoic acid conjugation and an increased cephalin flocculation.

There is an accumulation of nonprotein nitrogen in the plasma, 50 to 80 per cent of which is a residual fraction of as yet undetermined

nature The level of nonprotein nitrogen is of prognostic value Patients having 80 to 100 mg per 100 ml of plasma are critically ill and may die within a few days, and patients with over 100 mg per 100 ml of plasma almost invariably succumb²³ The probable source of this material is the burned area, at least in part²⁴ The substance or substances may simply be inert products of tissue breakdown or they may be toxins, but this has not been conclusively established If the accumulation is a sign of renal embarrassment, it is somewhat selective, for although the urea clearance is moderately reduced, there is no marked urea retention There is a tendency toward oliguria, but an adequate renal output can usually be maintained by proper administration of fluids An occasional patient with very extensive burns will go into complete renal shutdown There are probably multiple factors producing this renal damage Peripheral vasoconstriction and reduced blood flow may lead to anoxia of the renal parenchyma In the presence of acidosis and a reduced renal output the free hemoglobin in the plasma may be precipitated as acid methemoglobin, thus plugging the renal tubules²⁵

If the patient dies during the first two weeks after injury, the viscera show a flabby, water-logged appearance This is most noticeable in the kidneys, heart, adrenals, liver and brain There is a nephrosis with tubular damage, which is most marked in the proximal convoluted tubule Grossly the renal parenchyma shows a red orange color due to fatty infiltration There may be a few hemoglobin casts in the tubules²⁶

The adrenals show interstitial accumulation of fluid and degeneration of the cells in the zona fasciculata of the cortex It is perhaps significant that a similar lesion has been reported in patients dying of acute infections²⁷

The liver usually shows a moderate degree of fatty infiltration in the central portions of the lobule

Five cases have been reported as showing a diffuse ganglion cell degeneration and a vascular degeneration of nonspecific type that is most marked in the hypothalamus These patients died with sudden cessation of respiration while the heart continued to beat for ten or fifteen seconds It resembled the type of respiratory failure seen in intracranial lesions, particularly brain abscesses, where one minute the patient is fully conscious and talking and the next minute he suddenly dies²⁸ Similar histological changes have been reported in the piratubercular centers in dogs with experimental burns The lungs show no demonstrable pathology except when hot smoke has been inhaled

The lymph nodes in children or adolescents show a marked karyorrhexis that is not seen in adult patients²⁹

Period of Repair.—During this period the slough separates, second degree areas regenerate, and skin grafts are applied to the granulating areas of third degree burns The patient presents two major problems, infection and negative nitrogen balance The daily urinary nitrogen

excretion is often 20 to 30 gm, and patients with extensive granulating areas lose 30 to 40 gm a day from the wound¹¹ The hemoglobin level continues to remain low in spite of repeated transfusion There is apparently some destruction of cells within the body, as well as interference with red cell production In several reported cases this loss was 250 ml of packed cells a day This may be a systemic effect of the infection in the burned area³⁰ The bacteria invading the wound are characteristically hemolytic streptococci and staphylococci accompanied by gram negative rods such as *Bacillus pyocyaneus* *B proteus* and other coliform organisms

There is a markedly increased utilization of vitamins The existence of this demand has been suspected because of similar demands in other types of disease In particular, the requirement of vitamin C may be ten or fifteen times the normal amount^{3 31} This is important because there is probably a relation between this and the local hemorrhage with delayed healing often seen in the wounds There is also increased utilization of thiamine, riboflavin and nicotinic acid The fat soluble vitamins have not been thoroughly studied in this respect

The plasma protein nitrogen continues to be elevated but to lower levels than during the first week The urea clearance is somewhat below normal The albumin globulin ratio is lowered All these changes disappear as the granulating areas are covered with skin³¹

SYSTEMIC THERAPY

The patient must receive morphine for the relief of pain Care must be taken to give morphine directly into the circulation during the period of shock Cases have been reported in which the drug was given subcutaneously in repeated dosage without effect since the peripheral circulation was inadequate to transport the morphine Later when the circulation improved the drug was absorbed and dangerous overdose resulted³²

Top priority in the treatment of any severe burn must go to the administration of plasma An intravenous infusion must be started immediately and plasma given in amounts adequate to prevent hemoconcentration as judged by the blood hematocrit reading or hemoglobin level Blood for these examinations should be taken from large veins, to give an accurate picture of the state of the circulating blood There is adequate time after starting intravenous therapy to apply dressings

In addition to plasma the patient should also receive sodium in some form Experiments with scalded rats and mice show a significant decrease in mortality with the use of sodium solutions³³ A series of burn patients on the basis of these experiments were treated with large doses of one sixth molar sodium lactate given orally³⁴ This procedure may lead to marked alkalosis and in addition is often poorly

tolerated by the already nauseated patient. However, since administration of sodium is essential, and controlled doses of lactate aid in the restoration of the alkali reserve, the Shock Committee of the Committee on Medical Research of the National Research Council³³ recommends the use of a solution of two parts physiological saline solution and one part one-sixth molar sodium lactate.

In the years before the advent of convenient blood banks, with large stores of available plasma, burn shock was treated with whole blood. Then as plasma became available it was used preferentially because of the recognized hemoconcentration. Recent experiments have emphasized the treatment of burn shock with whole blood from the onset.³⁴ A series of patients so treated have shown less severe secondary anemia.³⁵ Apparently no deleterious effect results from allowing the hematocrit reading to rise to as high as 60 or 70 per cent cells when the blood volume is maintained. This report also emphasizes the necessity of adequate sodium administration, preferably by the oral route. Regardless of whether the initial shock is treated with whole blood alone or with plasma, the patient must receive repeated transfusions of whole blood until skin grafting is completed and the areas are healed.

Nitrogen Balance.—It is necessary to give these patients 300 or 400 gm of protein daily in order to maintain nitrogen balance. The administration of methionine has been said to reduce the urinary nitrogen excretion in experimentally burned rats.³⁷ This work, however, requires confirmation. Three grams of methionine administered daily to patients on a restricted diet after undergoing herniorrhaphy failed to exert a protein-sparing action as indicated by urinary nitrogen excretion.³⁸ In addition to a high protein, high carbohydrate, low fat diet, the patient should receive 1 or 2 gm a day of ascorbic acid, 50 mg of thiamine, 50 mg of riboflavin and 500 mg of nicotinamide.

Infection.—As previously stated, the invasion of the burned area by bacteria presents a major problem. There is some disagreement as to when the presence of infection starts to play a major role.^{39, 40} Some workers believe that infection is responsible for much of the adverse systemic effect that is apparent twenty-four hours after injury. Others have thought that infection was not marked until toward the end of the first week.⁴¹

The patient must be protected against tetanus by the administration of antitoxin or, in the case of those previously actively immunized against tetanus (such as military personnel), by the administration of a booster dose of tetanus toxoid. In addition he must receive systemic chemotherapy to combat the common pathogens in the wound and to prevent invasive infection. Penicillin is commonly given intramuscularly in a dosage of 250 000 units daily. However, it has been shown that gram negative rods such as the coliform group, *Bacillus proteus*, and *B. pyocyaneus*, common contaminants in burn wounds, destroy

penicillin in the wound and prevent its action on the gram positive cocci.⁴ In addition it has been reported that alpha streptococci and to a lesser extent gamma streptococci are not very susceptible to penicillin and tend to multiply in wounds in greater numbers beginning at the end of the second week.³⁰ In order to protect the patient fully it is advisable to use both penicillin parenterally and sulfadiazine orally. Dressings should be changed under aseptic precautions with the operators wearing masks to prevent contamination of the wound with nasopharyngeal organisms.

LOCAL THERAPY

The aim of local treatment is to protect the surface from contamination and if possible to prevent further plasma loss. The original purpose of the use of tannic acid was the sealing of the surface to minimize exudation,⁴³ but subsequent observation showed that it is absorbed through the burned surface with the production of liver damage. This has been confirmed by animal experiments.^{44, 45, 46} Tannic acid also causes additional coagulation necrosis of the living epithelium in the areas of second degree burn.⁴⁷ In a deep second degree burn the only living remnants of epidermis from which regeneration of the integument can occur are the bases of hair follicles and sweat glands in the dermis. If these islands are destroyed by tannic acid additional skin grafting becomes necessary. For these reasons most workers have abandoned tannic acid therapy in favor of the use of emollient dressings.

The burned area is gently cleansed with saline under sterile precautions, gross contamination with debris and also loose skin being removed in the process. Otherwise the area is disturbed as little as possible. The burn is covered with petrolatum gauze and subjected to compression through a layer of sterile mechanics waste held in place with an elastic bandage. This immobilizes the area and prevents the additional plasma loss that accompanies movement of a traumatized area. Some workers advocate the incorporation of sulfonamides in the ointment base for local application,⁴⁸ but it has been shown that many of the sulfonamides are absorbed through the burned surface often to a marked degree with resultant dangerously high blood levels of the drug.⁴⁹ For this reason administration by the oral route which is more easily controlled is preferred.

Removal of slough proceeds naturally through action of proteolytic enzymes in the tissue. The process unfortunately is relatively slow. Ideally dead tissue should be removed as quickly as possible to minimize infection and to permit early skin grafting thus keeping protein loss at a minimum. Pyruvic acid at a pH of 1.9 has been reported as hastening the separation process.⁵⁰ However this agent has recently been tested on standard experimental burns and the results indicate there is no advantage in its use. The action is apparently merely that

of wetting the wound, thus converting a dry gangrene into a wet gangrene⁵¹

Pending convincing demonstration of the efficacy of these adjuvants, general opinion favors spontaneous separation of slough aided by surgical débridement. When the general condition of the patient permits, the full thickness of the burn can be removed surgically and the area covered with split-thickness grafts. This is an ideal procedure that is limited only by the extensive surgery required in very large third degree burns.⁵²

THE BURN PROBLEM

The major points of controversy center about the causes of morbidity and mortality affecting the patient after he has emerged from shock. With the judicious use of blood, plasma and electrolyte solutions, it is possible to prolong the lives of all but the most severely burned patients beyond the initial shock period. Even under these conditions, the patient with a third degree burn of somewhat more than one third of the body surface usually dies within two weeks after injury.

The renal damage, while evident, is still not marked enough to cause death from renal failure. Some patients apparently have signs of increased intracranial pressure secondary to central nervous system damage. The abandonment of tannic acid therapy with resultant diminution in severity of liver damage has not resulted in any decrease in mortality.

The underlying cause of negative nitrogen balance, protracted secondary anemia and other less clearly demonstrated metabolic defects must be found in order to improve therapy.

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ADDITIONAL ARTICLES

METABOLIC DISTURBANCES SIMULATING ACUTE ABDOMINAL EMERGENCIES

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THAT extra abdominal medical conditions masquerade as intra abdominal diseases is a fact well known to the practicing physician. Patients come to mind who have presented signs and symptoms of a perforated peptic ulcer, or perhaps acute pancreatitis, or again acute painful seizures of cholecystic disease, but whose course of illness proved them to be suffering from acute coronary artery disease. One also recalls cases diagnosed as "acute appendicitis" that have proved to be frank pneumonia, diaphragmatic pleurisy or the onset of an acute infectious disease.

That disturbed states of metabolism enter into the differential diagnosis of abdominal disease is not generally appreciated, particularly when the onset of abdominal symptoms is sudden and severe in character. The physician's attention becomes riveted to an intra abdominal organ or organs not responsible for the condition. The patient may thus be subjected to the grave risk of an unnecessary exploratory operation.

The many extra abdominal conditions simulating acute surgical emergencies are noted in Table 1.

TABLE 1—EXTRA-ABDOMINAL CONDITIONS SIMULATING ACUTE SURGICAL EMERGENCY

Chest

Pneumonia especially in young children
Diaphragmatic pleurisy
Coronary occlusion
Angina pectoris
Pericarditis

Metabolic

Diabetic acidosis
Thyroid crisis
Acute adrenal insufficiency
Hypoglycemia
Hypoparathyroidism
Hyperthyroidism

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Central Nervous System

- Tabetic crisis
- Transverse myelitis
- Osteoarthritis of spine
- Tuberculosis of spine
- Scoliosis with arthritis
- Cerebral dysrhythmia (focal symptomatic epilepsy)¹⁶

Chronic Poisoning

- Lead, arsenic, mercury, emetine
- Bite of *Latrodectus mactans* (black widow spider)

Miscellaneous

- Onset of infectious disease
- Allergic states
- Henoch's purpura
- Herpes zoster
- Migraine

This discussion will present instances in which the acute signs and symptoms referable to the abdomen were due to a metabolic disturbance

DIABETES MELLITUS

Uncomplicated diabetes mellitus does not often produce abdominal symptoms. Diabetic ketosis, however, may manifest itself by acute abdominal pain, tenderness, nausea and vomiting. The muscular rigidity, leukocytosis and fever which often accompany the acidotic states may be puzzling and lead to unnecessary surgical exploration. The diagnosis of an acute intra-abdominal disease in the presence of diabetic acidosis should be made with caution. Before undertaking surgery, laboratory studies for acidosis (carbon dioxide combining power, blood sugar determination, and the like) are essential, and if the findings are abnormal the results of a trial with insulin and other measures should be noted.

Case I. Ketosis Simulating Acute Surgical Abdomen

W. T., a man aged 19, had had diabetes mellitus for four years. The diabetic state was controlled adequately by insulin and a dietary regimen. While on vacation he digressed from his diet and a few days later was seized with an attack of nausea, vomiting and violent abdominal pain. He had not had a bowel movement for two days. An enema was ineffective. The attending local physician was of the opinion that the patient had an intestinal obstructive lesion. Abdominal pains became so intense that he was given a hypodermic injection of morphine sulfate $\frac{1}{4}$ grain and atropine sulfate $\frac{1}{4}$ grain. These relieved him for a short time. Upon his admission to the Temple University Hospital the patient was observed twisting, turning and groaning with pain. There was a marked acetone odor to his breath. The temperature was 103° F., pulse 132. The abdomen was flat, slightly resistant and had general soreness. Pristalsis was present. The blood count showed 18,800 leukocytes per cubic millimeter with a 92 per cent polymorphonuclear leukocyte differential count. The blood sugar content was 480 mg. per 100 cc., and the carbon dioxide combining capacity was 17 per cent.

The differential diagnosis was between severe diabetic acidosis and acute abdominal disease precipitating acidosis in a diabetic patient. Dr. W. Emory Burnett

who saw the patient with me agreed that the symptom complex was probably metabolic rather than surgical in nature. The patient was treated vigorously for impending coma by large doses of insulin, replacement of fluids by venoclysis by podermoclysis and other conventional measures such as washing of the stomach.

risen to 44 per cent. The patient made an uneventful recovery and left the hospital on the seventh day after admission on a standard diet and 80 units of insulin daily.

Comment—This patient was stricken with acute abdominal pain, obstipation, nausea, vomiting, a rise in temperature and leukocytosis. It is not surprising that he was sent to the hospital with a surgical diagnosis. The abdominal tenderness, however, was widespread rather than localized, and the abdominal symptoms, leukocytosis and fever, subsided rapidly after the insulin and fluid administration. In an intra-abdominal lesion, on the other hand, the tenderness is more localized and the pain, leukocytosis and fever persist or increase in spite of treatment for acidosis. The cause of leukocytosis and fever has not been adequately explained. That there is a profound dehydration in diabetic acidosis is well known. This may account for the leukocytosis and fever. Peters,¹ Lawrence, Lucas and McCance² and others are of the opinion that the leukocytosis and a shift to the left in the Schilling count are due to bone marrow stimulation by ketone bodies.

We must bear in mind, however, that a patient with a diabetic acidosis may also suffer from an intercurrent abdominal disease such as an acute appendicitis which will precipitate acidosis. However, Case I and the following history teach us a lesson that in an acute abdominal emergency, if the patient is known to be a victim of a metabolic disease, the abdominal symptoms may be metabolic in origin and unrelated to a surgical condition of the abdomen. A brief trial with anti-ketosis therapy will usually clarify the problem.

Case II Borderline Acidosis Masking Acute Appendicitis

A diabetic girl, aged 16, entered the Philadelphia General Hospital service of Dr. A. S. Dorn with a history of nausea, vomiting for forty-eight hours and abdominal pain. There was definite tenderness and rigidity in the right lower quadrant, peristalsis was present but hypoactive, the temperature was 99° F., the pulse 104, respiration 22, leukocyte count 18,000 and polymorphonuclears 86 per cent. The urine was positive for sugar and the carbon dioxide combining power was 42 volume per cent with a blood sugar of 109 mg. per cent. Surgical consultations on two occasions suggested the diagnosis of acute appendicitis and the patient was operated upon. Neither abdominal nor pelvic disease was found. The appendix was removed, however, and upon histologic examination proved to be normal. Fortunately, she made a good recovery on a diabetic regimen, although her blood sugar had risen the day after the operation to 352 mg. per 100 cc.

Comment—In this instance the operation was the safer procedure, bearing out the dictum of Joslin,³ "If in doubt operate, although you may make an occasional mistake." Because symptoms of diabetic acidosis may simulate an acute surgical disease of the abdomen, one

may overlook acute intra-abdominal disease and deny the patient the benefit of surgical intervention with subsequent disastrous results. Acidosis per se must not be allowed to cloud a surgical condition, as in the following experiences, in one of which the patient not operated on died and in the second, (Case IV) surgery was life saving.

Case III. Diabetic Ketosis Associated with Gangrenous Appendicitis and Suppurative Peritonitis

I F, a woman aged 57 years, was admitted to the Philadelphia General Hospital, service of Dr A. Sandom, with a history of persistent vomiting and diarrhea for two days before admission to the hospital. Four days before admission the patient had complained of weakness and right lower quadrant pain. On examination she was found to be toxic, drowsy and dehydrated. The chest was clear except for a few moist rales at both bases. The abdomen was soft, and there was no tenderness or rigidity. The pelvis was normal except for a laceration of the cervix. The temperature was 101° F, pulse 98, respiration 36. The leukocyte count was 17,200 per cubic millimeter with a polymorphonuclear count of 85 per cent. The blood sugar content was 580 mg per 100 cc and the carbon dioxide combining power 39 volumes per cent. The patient was treated for acidosis, but twenty-four hours later her temperature had risen to 106° F, the pulse had become weak and rapid and she died thirty hours after admission to the hospital. The autopsy showed diffuse generalized suppurative peritonitis secondary to a ruptured gangrenous appendix.

Case IV. Diabetes and Acute Ruptured Gangrenous Appendicitis and Peritonitis; Recovery after Operation

S T, a man aged 33 years, known to have moderately severe diabetes, partially controlled with insulin and diet, was uncooperative in previous attempts at management. He was seen as an outpatient fifty-six hours before admission to the Temple University Hospital, complaining of tightness in the chest, general malaise and obstinate constipation.

On admission the temperature was 98.8° F, pulse 72, blood pressure 120/80. The blood sugar was 207 mg per 100 cc, hemoglobin 15 gm per 100 cc, erythrocytes 4,800,000 per cubic millimeter, polymorphonuclear neutrophils 78 per cent, lymphocytes 22 per cent. The electrocardiogram was essentially normal. An enema was advised and insulin was increased to 20 units of protamine zinc daily. The patient carried on normal business activities for twenty-four hours. Six hours before admission to the hospital he was seized with violent diffuse abdominal pains. The tightness in the chest disappeared. The constipation was not relieved by an enema and the patient took a laxative without results.

On physical examination the heart and lungs were negative. There was no fever, no tachycardia. The abdomen was mildly distended, there was hyporeactive peristalsis, with a slight tenderness in the right lower quadrant, but no rigidity. The rectal examination was negative. The differential diagnosis was between impending diabetic coma as a cause of the abdominal pain and acute intra-abdominal disease. Laboratory studies showed the plasma carbon dioxide combining power 62 volumes per cent, blood sugar 162 mg per 100 cc. The blood count was hemoglobin 15.4 gm per 100 cc, erythrocytes 5,500,000 per cubic millimeter of blood, leukocytes 18,900 per cubic millimeter of blood, polymorphonuclear neutrophils 89 per cent, lymphocytes 5 per cent, monocytes 6 per cent. A flat plate x-ray examination of the abdomen showed that the transverse colon was moderately distended with gas. However, some gas and fecal material were seen along the course of the descending colon and in the iliac colon as in the cecum. No small bowel gas was present. The amount and distribution of the gas was such that we could not make a diagnosis of intestinal obstruction.

Within a few hours during which the laboratory studies were made the physical signs changed. The temperature rose to 103° F, the pulse to 120. The abdomen became distended and there was tenderness to palpation over the lower abdomen, more so over the right lower quadrant. The patient was operated upon by Dr. W. Wayne Babcock. The gross findings were as follows: the appendix was about 2 cm. thick, dark red, bound down posteriorly. There was a perforation about 15 to 20 mm. in diameter at about the midpoint. About 8 ounces of fetid yellow fluid with gas was evacuated from the colon. Thin serous pus had collected in the general peritoneal cavity. The general peritoneum was only lightly injected. The operation was appendectomy with drainage. The patient was given 30,000 units of penicillin every two hours and glucose in saline solution intravenously. Insulin was administered, varying in dosage according to the blood sugar level.

Comment—These two cases demonstrate the importance of immediate surgical intervention when an acute abdominal lesion cannot be eliminated even in the presence of acidosis. If time permits it is safer of course to delay surgery until the acidosis is controlled (carbon dioxide combining power of 40 or above). Even with a blood sugar content two or three times the normal levels an operation can if necessary be undertaken with a fair degree of safety.

The more diabetic patients with abdominal lesions one sees the more one gains the impression that the symptoms of an intra-abdominal disease in a diabetic are less severe and more insidious than in a nondiabetic under similar conditions.^{4, 44}

HYPOLYCEMIA

The clinical state of hypoglycemia reflects involvement of the central nervous system.^{5b} Symptoms referable to organ systems other than the central nervous system are indicative of either stimulation of the sympathetic-adrenal system (pallor, rapid pulse, profuse sweating and dilatation of pupils) or overactivity of the parasympathetic system (bradycardia and increased contraction of various segments of the gastrointestinal tract including the biliary tract).^{5a} When the latter symptoms predominate abdominal pain may be a prominent clinical sign and be misinterpreted as due to intra-abdominal disease such as peptic ulcer or biliary colic.⁷ The erroneous diagnosis of peptic ulcer may further be complicated by the fact that frequent feedings of a bland diet relieve the hypoglycemia as well as peptic ulcer. Peskin⁶ has observed such a group of patients who attended a gastrointestinal clinic and were resistant to the ordinary orthodox ulcer treatment. When the patients were studied from the point of view of a metabolic disorder hypoglycemia was found. They were treated for it and the gastric symptoms regarded as due to peptic ulcer promptly subsided with no recurrence of complaints. Harris⁷ in an earlier publication called attention to the occasional difficulty in differentiating from the symptoms alone between hyperinsulinism and duodenal ulcer.

Case V. Hypoglycemia with Symptoms Simulating Duodenal Ulcer

I B, a man aged 47, was admitted to the Temple University Hospital with a diagnosis of duodenal ulcer. The diagnosis was based on gastric symptoms of eructations of gas, heartburn and abdominal pains occurring three hours after meals and relieved by food. X ray examination showed an irregular spastic duodenal cap. The patient responded well to the Sippy regimen of frequent feedings and alkali powders. He left the hospital. One week later he was readmitted to the Northern Liberties Hospital with the following history. On the evening before admission to the hospital he became extremely weak, cold and clammy, and had severe cramplike pains in the abdomen. This occurred about two and one-half hours after his last meal. A local physician saw him during the attack and, learning of the history of a duodenal ulcer, was of the opinion that the patient had a "gastric hemorrhage." The patient felt hungry and was given milk and cream. His pains subsided and his general condition improved. Upon admission to the hospital next morning he had an attack of weakness and dizziness. He was given one half glass of milk and cream and the symptoms subsided within a few minutes.

On examination the patient appeared to be in good clinical condition. His pulse rate was 72 per minute, regular and of good quality, blood pressure 125/70 and respiratory rate 20 per minute. The heart and lungs were clear. Examination of the abdomen showed slight gaseous distention. Rectal examination revealed no tarry fecal matter. The next day the patient was given a glucose tolerance test which was as follows: fasting 74 mg., one hour after glucose 211 mg., two hours 200 mg., three hours 170 mg., four hours 111 mg., five hours 65 mg.

After the fifth hour the patient became weak and nervous and perspired excessively. He complained of abdominal pain and tightness in the chest. He was given orange juice, and relief followed within a few moments. He was placed on a regular house diet, it was, however, of high protein, moderate carbohydrate and low fat content.⁸ He remained at the hospital for seven days and was symptom free. He then left the hospital in good condition and remained symptom free. X ray examination of the gastrointestinal tract four weeks later showed no evidence of intrinsic lesion of the stomach or duodenum.

Comment—The patient had symptoms of peptic ulcer. On the basis of these and x ray findings of an irregular and spastic cap, the diagnosis of a duodenal ulcer was made. The fact that the gastric pains, occurring at the hypoglycemia level of the sugar tolerance curve, were relieved by ingestion of orange juice would speak against the existence of a duodenal ulcer. The patient was completely relieved of gastric symptoms on a high protein diet. That hypoglycemia can produce gastric hypermotility, spasm and augment gastric secretion was pointed out by several investigators.^{9, 10, 10a} The stimulatory impulses from the central nervous system induced by hypoglycemia are said to be transmitted over the vagi. The x ray findings of an irregular spastic duodenal cap are probably to be explained on this basis. Thus the clinical mimicry of hypoglycemia as peptic ulcer might be so close as to cause the unwary considerable confusion. On the other hand, the possibility of the simultaneous occurrence of peptic ulcer and hypoglycemia is to be borne in mind.

The abdominal pain in hypoglycemic patients may be localized to the right upper quadrant with radiation to the back and shoulder or to either of the lower quadrants. Sander¹¹ has recently reported five

rather than a surgical condition. Nevertheless, an acute surgical condition in the abdomen may coexist in a patient suffering with a metabolic disorder. The existence of a complicating intra abdominal surgical lesion may be difficult to exclude without x ray and laboratory studies or exploratory laparotomy. In all such instances the combined judgment of both internist and surgeon will prevent unnecessary surgical intervention. On the other hand, if an acute intra abdominal lesion is found to exist, the combined judgment of the internist and surgeon in selection of operative time and guidance of the preoperative and postoperative course cannot but work to the best advantage of the patient.

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THE SURGICAL TREATMENT OF CHRONIC INFECTED PILONIDAL SINUS

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THE many papers which have appeared during and since the war on the subject of the surgical treatment of pilonidal sinus bear testimony that the problem is not a simple one. The chronically infected pilonidal sinus was a major concern of the military surgeon. Reports from the Office of the Surgeon General¹ show that approximately 11 000 cases of pilonidal cyst or sinus were treated in the continental United States in 1942 and approximately 21 000 in 1943. Although it is generally conceded that the most desirable method of treatment is one which will completely eliminate the sinus at the wound by primary suture at the time of excision, the use of this method of treatment resulted in so many recurrences and failures to obtain the desired primary healing that surgeons were admonished by the Surgeon General's Office to refrain from radical excision and resort to simple incision and drainage of abscesses as they occurred. Excision of the sinus was authorized only if, in the opinion of the operating surgeon, it was absolutely necessary. In view of the large number of cases of pilonidal sinus which developed during the war, there is no doubt that doctors in civil practice will now see an increased number of recurrent infected pilonidal sinuses. For this reason we present a method of excision with suture in which wound healing by primary union occurred in over 80 per cent of the cases and a pilonidal sinus requiring reoperation was encountered in only one instance.

ORIGIN OF PILONIDAL SINUS

The true origin of pilonidal sinus is still debated. Gage² believes it arises from "an anomalous development of the medullary canal at the coccygeal dimple results from disturbance in the development of the coccygeal ligament and is not connected with the meninges." Stone³ offers the ingenious opinion that the sinuses are vestigial remnants of the preen gland found near the tail of birds. However, on the basis of operative findings we agree with Fox⁴ that the origin is in the skin ectoderm and is not neurogenic or enteric. He believes that the sinuses arise from a process of skin invagination during the third and fourth months of embryonic life.

The origin of so-called recurrent pilonidal sinus is also debated. Doubtless a few of these arise from a portion of the sinus

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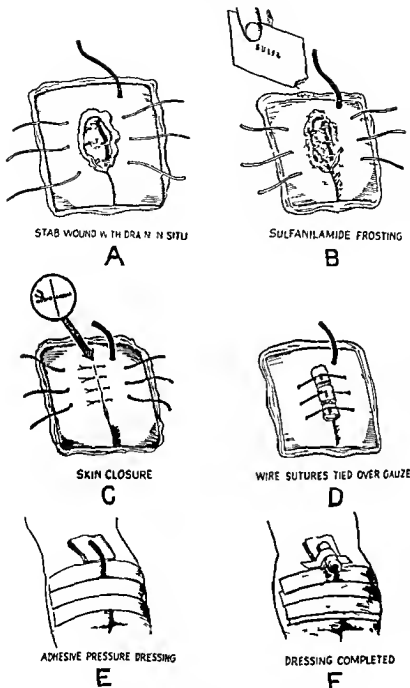


Fig 540

The wire sutures are then tied firmly over bolsters of gauze (Fig 540 D) dead space being thus obliterated. Tension is further re-

moved from the suture line by adhesive strapping applied over fluffed gauze and sterile cotton waste (Fig 540, E) The drainage tube emerges between adhesive strips and its end is enclosed in a piece of gauze (Fig 540 F) This permits easy access to the tube, which may be removed readily without disturbing the dressing seventy two hours after operation The patient is encouraged to lie on his back after operation, for it is believed the pressure so obtained aids in obliterating dead space The first dressing is done seven days after operation, ambulation is not permitted until the eighth to the tenth postoperative day, depending on the appearance of the wound

RESULTS OF OPERATION

It is generally agreed that the factors most commonly responsible for faulty healing in primary closure after removal of a pilonidal sinus are (1) infection, (2) failure to obtain complete hemostasis and (3) failure to obliterate dead space The outlined procedure is designed to control these factors

The wound surface following removal of a pilonidal sinus is potentially infected in every case Cultures made from the walls of sinuses removed in this series showed the staphylococcus to be the predominant infecting organism Penicillin is known to be more effective than the sulfonamides in combating staphylococcic infections Barnett⁷ in an article which appeared during the course of this study, states that he has used penicillin by squirting it into all corners of the pilonidal wound and into the walls of the cavity by needle and syringe at the time of operation The number of cases he treated was insufficient to warrant any conclusions as to the value of the method

Absolute hemostasis, which is desirable to assure the success of primary wound closure, is often difficult to obtain, and even when the wound appears completely dry the insertion of sutures for wound closure may reactivate bleeding points For this reason, we have for some time placed a drain in all pilonidal wounds By far the most satisfactory method has been the *stab wound near the upper angle of the incision with a piece of Dakin tubing as the drain material* Even in wounds considered completely dry at closure serosanguineous drainage subsequent to the dressing has been sufficient to justify the use of a drain A stab wound invariably heals promptly, whereas drains brought out through the wound commonly leave a residual sinus that delays recovery or constitutes a portal of entry for reinfection and in growth of hair

Most of the twenty five patients treated by the operative technic outlined above, in conjunction with the use of penicillin, had been operated on by various technics at least once before, and in one case nine previous attempts at excision and plastic repair had been made elsewhere In seven cases in which cultures of the sinus were made *Staphylococcus albus* or *S aureus* was found In one case a hemolytic

streptococcus was recovered. One patient required reoperation for the cure of a residual sinus. The wound failed to heal per primam in three others, there being a slight separation of the skin edges which healed by granulation. Healing was by primary union in twenty cases.

TECHNIC OF PENICILLIN THERAPY

Penicillin was administered according to the following method. Intramuscular injections of 20 000 units dissolved in 2 cc of distilled water were given every three hours for two days before operation and four days after operation. In addition to that given intramuscularly 20 000 units dissolved in 20 cc of normal saline solution was injected through the drainage tube on the day of operation. This procedure was repeated forty eight hours later and the tube was removed seventy two hours after operation. Sulfadiazine in dosage of 1 gm every four hours was given concurrently during the period of penicillin therapy.

SUMMARY AND CONCLUSIONS

A simple method of radical excision with primary closure of chronic infected pilonidal sinuses is described. The use of penicillin and sulfo namides as an aid in preoperative and postoperative treatment is discussed. The method outlined has resulted in more cases of primary healing, shorter convalescence and fewer failures than any method with which we are personally familiar.

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